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ORGANIZATIONAL HEALTHY EXISTENCE CHALLENGES: A CASE STUDY OF THE
TECHNOLOGY PARK OF THE FEDERAL UNIVERSITY OF RIO DE JANEIRO (PTEC-
UFRJ)

RIO DE JANEIRO

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Master's dissertation presented to the
COPPEAD Graduate School of Business,
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part of the mandatory requirements in order to
obtain the title of Master in Business
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Advisor: Prof. Denise Lima Fleck, Ph.D.

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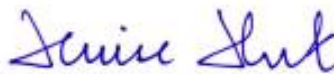
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RESUMO

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Parques Tecnológicos são um fenômeno popular globalmente para a promoção de Inovação Tecnológica, e, em última instância, desenvolvimento socio-econômico. Após os primeiros casos de sucesso aparecerem nos Estados Unidos da América – especialmente o Stanford Research Park, comumente creditado pela origem do Vale do Silício –, muitas universidades e institutos de pesquisa pelo mundo movimentaram-se para estabelecer seus próprios Parques Tecnológicos e, idealmente, atingir resultados semelhantes. Eventualmente Parques Tecnológicos tornaram-se uma ferramenta popular entre atores de política pública que desejam aumentar a competitividade de regiões, e nações, em setores de alta tecnologia. Não foi diferente no Brasil, onde Parques Tecnológicos entraram em popularidade durante as últimas três décadas, também com suporte governamental na tentativa de elevar a competitividade do país em mercados globais de tecnologia de ponta, nos quais o Brasil historicamente tem performado abaixo do ideal, com algumas poucas exceções. Enquanto grande ênfase tem sido dada na literatura para a análise de Parques Tecnológicos em termos de performance na geração de Inovação e impacto socio-econômico, este trabalho se propõe a analisar um Parque Tecnológico em termos de desafios gerenciais para a existência organizacional continuada, necessária para que parques atinjam seus objetivos finalísticos. Para isso, um estudo longitudinal foi conduzido em forma de estudo de caso do Parque Tecnológico da Universidade Federal do Rio de Janeiro (PTEC-UFRJ), comumente reconhecido como um dos exemplos de Parques Tecnológicos de maior sucesso no Brasil. Uma perspectiva histórica do parque é apresentada, junto com dados relevantes do ambiente, para uma análise nos termos do modelo teórico de crescimento organizacional desenvolvido por Fleck (2009). Como contribuição secundária, uma lista de seis desafios identificados na administração do PTEC-UFRJ, que podem ser potencialmente relevantes para outros Parques Tecnológicos (em contextos similares), emergiu da análise primária realizada à luz do modelo de Fleck (2009).

Keywords: Parques Tecnológicos; Integridade Organizacional; Sobrevivência Organizacional de Longo Prazo; Estudo de Caso Longitudinal; Universidades Públicas Brasileiras; Administração;

ABSTRACT

TSUDA, Tutmés Bertin. **Organizational healthy existence challenges:** a case study of the technology park of the Federal University of Rio De Janeiro (PTEC-UFRJ). Rio de Janeiro, 2021. 276 pp. Dissertation (Master's Degree in Business Administration) - COPPEAD Graduate School of Business, Federal University of Rio de Janeiro, Rio de Janeiro, 2020.

Technology Parks are a popular phenomenon around the world for the promotion of technological innovation and, ultimately, socio-economic development. After the first successful cases arose in the United States of America – especially the Stanford Science Park, widely credited with originating the Silicon Valley –, many universities and research institutes around the world rushed to establish their own Technology Parks and hopefully achieve similar results, and Technology Parks eventually became a popular tool among public policy makers wishing to increase the competitiveness of entire nations in high technology sectors. This was no different in Brazil, where Technology Parks found their way into popularity over the last three decades, much aided by government efforts seeking to elevate the country's competitiveness into the global markets of high-end technology, where Brazil has historically been a low performer, with some exceptions. While great emphasis has been placed in the literature for the analysis of Technology Parks in terms of performance for generating innovation and socio-economic impact, this work analyzes a Technology Park in terms of managerial challenges for organizational continued existence. For that, a longitudinal study was conducted as a case study of the Technology Park of the Federal University of Rio de Janeiro (PTEC-UFRJ), widely regarded as one of the most successful examples of Technology Parks in Brazil. A historical account of the park is provided, along with relevant environmental data, to be analysed under the theoretical model set forth by Fleck (2009). As a secondary contribution, a list of six challenges pertaining to the management of PTEC-UFRJ that could potentially be faced by other Technology Parks (under similar contexts) has emerged from the primary analysis made in the light of Fleck's model.

Keywords: Technology Parks; Organizational Integrity; Organizational Long-Term Survival; Longitudinal Case Study; Brazilian Public Universities; Management;

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LIST OF ABBREVIATIONS

ABDI	Brazilian Association for Industrial Development
ABVCAP	Brazilian Association of Private Equity and Venture Capital
ANP	National Agency of Petroleum, Natural Gas and Biofuels
ANPEI	National Association for Research and Development of Innovative Enterprises
ANPROTEC	National Association for Entities Promoting Innovative Enterprises
ARD	American Research & Development Corporation
BNDES	Brazilian Development Bank
BRL	Brazilian Real (Currency)
CAPES	Coordination for Development of Higher Education Personnel
CENPES	Leopoldo Américo Miguez de Mello Research and Development Center (Petrobras)
CETIC	Excellence Center in Information and Communication Technology (Office building at PTEC-UFRJ)
CETIQT	Technology Center for Chemical and Textile Industries (SENAI)
CNAP	Center for Training and Research in Oil (Petrobras)
CNP	National Petroleum Council
CNPq	National Council for Scientific and Technological Development
COPPE	Alberto Luiz Coimbra Institute of Engineering Post-Graduation and Research
E&P	Exploration and Production (oil & gas)
EIRMA	European Industrial Research Management Association
EMBRAPA	Brazilian Agricultural Research Corporation
EMBRAPII	Brazilian Corporation for Research and Industrial Innovation
ENCTI	The National Strategy for Science Technology and Innovation
FAPERJ	Rio de Janeiro State's Foundation for Supporting Research
FCCSA	Carioca Factory of Catalysts
FFCL	Francisco Campos Philosophy, Science, and Languages School
FINEP	Financier of Studies and Projects
Fiocruz	Oswaldo Cruz Foundation
FNDCT	National Fund for Scientific and Technological Development
FPSO	Floating Production Storage and Offload
GDP	Gross National Product
GE	General Electric
GERD	Gross Domestic Expenditure on Research and Development
GL	Lei do Bem ("The Good Law")
IASP	International Association of Science Parks
IBGE	Brazilian Institute of Geography and Statistics
ICT	Information and Communication Technology
IL	Lei de Informática (Informatics Law)
INT	National Technology Institute
IP	Intellectual Property
IPAs	Institutional Patent Agreements
IPI	Tax over Industrialized Products
IRI	American Industrial Research institute

ISS	Tax Over Services of Any Nature
ITA	Aeronautics Technology Institute
JC	Junior Company
LNG	Liquified Natural Gas
MCTIC	Brazilian Ministry of Science, Technology, Information and Communications
ME	Brazilian Ministry of Economy
MEC	Brazilian Ministry of Education
NI	New Institutionalism
NIS	National Innovation System
NIT	Technology Innovation Nucleus (Núcleo de Inovação Tecnológica)
OECD	Organisation for Economic Co-operation and Development
OI	Old Institutionalism
OS	Social Organization (Organização Social)
PACTI	the National Program For Supporting Industry's Technological
Capacitation	
PACTo	Management Program for Science and Technology (USP)
PBM	Bigger Brazil Plan (Plano Brasil Maior)
PDTI / PDTA	Program for Technological Capacitation of the Industry and Agropecuary
PhD	Doctor of Philosophy
PINTEC	Industrial Survey of Technological Innovation (IBGE)
PNI	National Program for Supporting Business Incubators & Technology Parks
PNPG	National Post-Graduation Plan
PPB	Basic Production Process
PPSA	Pré-Sal Petróleo S.A. (Company)
PTEC-UFRJ	Technology Park of the Federal University of Rio de Janeiro
R&D	Research and Development
R&D&I	Research, Development and Innovation
ReINC	Rio de Janeiro's Network for Promoters of Innovative Enterprises
RNP	National Research Network
S&T	Science and Technology
S&T&I	Science, Technology and Innovation
SENAI	National Service for Industrial Learning
SMEs	Small and Medium Enterprises
SSP	Singapore Technology Park
Tecnopuc	Technology Park of the Pontifical Catholic University of Rio Grande do Sul
TP	Technology Park
TTO	Technology Transfer Office
TusPark	Tsinghua University Technology Park
UERJ	State University of Rio de Janeiro
UFF	Federal Fluminense University
UFRJ	Federal University of Rio de Janeiro
UFRN	Federal University of Rio Grande do Norte
UFRRJ	Federal Rural University of Rio de Janeiro
UFRS	Federal University of Rio Grande do Sul

UK	United Kingdom
UN	United Nations
UNB	University of Brasilia
UNESCO	The United Nations Educational, Scientific and Cultural Organization
US	United States
USA	United States of America
USD	United States Dollar
USP	University of São Paulo
UWD	Ultra-Deep Waters
VC	Venture Capital
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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1 Introduction

Technology Parks as instruments for promoting technological innovation. In hopes of causing positive impacts to regional economic development, they have proven to be a popular choice among policy makers throughout the world, inasmuch they are seen as an effective tool to create environments where interactions between the academia and the private sector is facilitated. By congregating a number of services and key actors, the parks are expected to spark synergies, develop a culture of innovation, and support enterprises in a varied set of needs (Anprotec, 2008).

The idea of achieving sustained economic development has grown intricately linked to the extent of technological innovation capacities available in a country. Developed countries, in general, have exhibited soaring levels of innovative technological outputs over the past decades. Typical examples include South Korea, Taiwan, Israel and Singapore, which have managed to achieve great levels of economic growth and social development in recent history, having provided a spotlight for the critical role of science, technology and innovation in supporting economic growth (Matias-Pereira and Kruglianskas, 2005).

The initial optimism with the effectiveness of Technology Parks during the first generation, kick-off by the Stanford Science Park, which gave birth to the Silicon Valley, (Anprotec, 2008) was later replaced by a more critical view in face of modest results found through the evaluation of some Technology Parks that followed (Vedovello, Judice, and Maculan, 2006). However, the very definition of what are the adequate tools to assess Technology Parks has been up for debate. A movement in the innovation literature has been happening in order to develop models to analyse Technology Parks and their impacts. Phan, Siegel, and Wright (2005) observed that the development of theory made specifically to understand and assess Technology Parks was proving difficult, due to, among other things, their multi-level nature that is challenging to integrate, a need for further conceptual development of the adequate variables, and the high variance of models that Technology Parks present.

Different frameworks and contributions in this area have been made over the years, notably: Guy (1996), Hogan (1996), Staton (1996), UKSPA (2003), Koh, Koh, and Tschang (2005), Monck and Peters (2009). One characteristic shared by all of the aforementioned works is that the assessment of Technology Parks is sought in light of impact or performance indicators. Commonly, these assessments will take into

consideration data, such as the sources of financing, number of companies, size of resident companies, number of joint R&D projects, occupancy rate, jobs generated, degree of satisfaction, among others.

However, regardless of whether or not a Technology Park is successfully generating innovation and positively impacting the socio-economic development of a region, it might still cease to exist due to inadequate responses to managerial challenges not directly related to fostering innovation. Therefore, the assessment of successful innovation, interactions, and economic impact of a specific Technology Park does not exclude the need for an assessment made in light of strategic management theory.

It is true that Technology Parks could theoretically be kept alive even in the absence of adequate management, especially due to government interventions. However, while public funding is indeed expected to be an important resource for Technology Parks, and parks born inside public universities will naturally utilize public resources, authors such as Koh, Koh, and Tschang (2005) have suggested that a transition from government-led growth to private-led growth is desirable, and Radošević and Myrzakhmet (2009) have suggested that:

The key point is to distinguish between support for TP activities (cooperation with R&D and higher education institutions, active management of TT [Technology Transfer], and support for technology-intensive activities) and support for TPs as organisations. Rather than focusing on TPs as organisations, policy should focus on and prioritise support, first, to innovation projects (grants), second, to the people who will be involved in managing innovation projects (skills) and, third to supporting TPs as organisations. (Radošević and Myrzakhmet, 2009, p. 655)

In summary, it is not desirable that Technology Parks, over the long term, continue to exist on “life-support” from governmental interventions. Although such state of existence can be expected, or even necessary, to enable parks to come into life and function during their early stages of existence (Koh, Koh, and Tschang, 2005; Radošević and Myrzakhmet, 2009). For this reason, this work separates the analysis of Technology Parks into socio-economic impact and responses to managerial challenges, focusing on the later.

The literature on assessment of Technology Parks tends to place great emphasis on impact or performance measurements. However, we propose that an analysis in the light of strategic management (not necessarily pertaining to themes of innovation) is also relevant, because Technology Parks may cease to exist if growth-

related managerial challenges are not properly addressed. In addition, continued failure to generate significant innovation and socio-economic impact will affect their legitimacy and relevance in society, which Fleck's (2009) navigating challenge and organizational integrity condition may indirectly capture.

Following this line, the present study has investigated the Technology Park of the Federal University of Rio de Janeiro (PTEC-UFRJ) in the light of Fleck's (2009) organizational growth challenges – a theoretical perspective that distinguishes healthier and less healthy organizational existences. PTEC-UFRJ is one of the most prominent Technology Parks in Brazil, notorious for receiving multiple multinational companies during a fast growth period in the last decade. The theoretical framework applied here concerns general management challenges faced by organizations that undergo growth, where evidence of adequate (or inadequate) responses, analysed through longitudinal data, may indicate a propensity to self-perpetuation (or self-destruction) of the target organization.

Analyzing PTEC-UFRJ in light of this framework seeks to provide insights into the following research question: **what challenges do Brazilian Technology Parks located in public universities face for fostering a healthy existence?** While the primary output of the work is the analysis of PTEC-UFRJ in terms of its responses to the challenges of growth (Fleck, 2009), a secondary objective is set at identifying management challenges that may be relevant for the planning and implementation of other Technology Parks in the country, as these naturally arise out of the primary analysis.

1.1 Structure

This work will be structured in seven sections. This introduction consists of the first section, providing background information on the subject in order to expose its relevance and the research question. The second section will go into the literature review, starting with a brief review on Technology Parks, and ending at the theoretical model applied for data analysis in this research. Third section will expose the methodology for data collection and analysis. The fourth section will present the institutional environment where the case study is situated. Section five will be

dedicated to the historical information regarding PTEC-UFRJ. Section six will delve into the analysis of the case in light of the theoretical model utilized. Section seven will provide a discussion of the data analysed in terms of what insights generated during the analysis might be relevant for other Technology Parks. Eight and last section will forward final considerations and address the limitations of this work.

2 Literature review

Section 2.1 will present a brief review on the theme of innovation through university-industry interactions. This is the background necessary to contextualize the existence of Technology Parks, the reasons for which they are created. Section 2.2 will focus on definitions and relevant themes of Technology Parks itself. Section 2.3 will present the theoretical lens to be applied in this work for the case study analysis, the Archetypes of Organizational Success and Failure as modes of responding to the five challenges of growth set forth by Fleck (2009).

2.1 Innovation through university-industry interactions

Technology Parks are located at the intersection of the university, government, and industry, serving as a mechanism to promote technological innovation through articulations between those three spheres. This subsection will be dedicated to providing some understanding about the broader context in which Technology Parks were born and continue to exist.

2.1.1 Technological innovation

Perlin et al. (2018) claim that technological innovation plays a major role in social and economic development. Cameron (1998) observed that such connection between innovation and economic development has been vastly explored by many academics through empirical research, concluding that “a consensus has emerged that innovation has a significant effect on productivity at the level of the firm, industry and country” (p. 21). Garnica, Oliveira, and Torkomian (2006), note that “innovation has been considered for some decades as one of the fundamental elements for economic and technical progress, especially after the contributions of Schumpeter in the 1950s” (p. 1). More recently, examples such as Hasan, and Tucci (2010) continue to confirm a positive link between innovation and economic development.

Plonski (2005) defines technological innovation as “technological changes to products (goods or services) offered to society, or to the means through which the products are created and offered (usually called process innovation)” (p. 27), these changes can further be categorized into “incremental, radical or transformative” (p. 28). This definition, however, only takes into consideration the output of innovation. Reis

(2004), develops a definition for technological innovation which takes a more holistic account. The author asserts that technological innovation is the conjunction of systematic and coordinated actions made to introduce knowledge into the development of new products and productive processes, or into changes to some attributes of existing processes, products, or services. This definition takes a strong emphasis to a deliberate and planned facet of innovation (systematic and coordinated), and to the necessary presence of knowledge as a foundation for the technological innovations.

2.1.2 Universities as central sources of knowledge for technological innovation

Ranga and Etzkowitz (2013) propose that potential for innovation “lies in a more prominent role of the university [...]” (p. 238). As early as 1968, Jorge Sabato, along with Natalino Botana, had proposed the ideas of what is now known as the Sabato Triangle (Plonski, 1995). According to Plonski (1995), Sabato and Botana proposed that, in order for Latin America to economically develop, efforts should be undertaken to advance scientific and technological research. They asserted that science and technology are catalysts of social change. Put simply, the Sabato Triangle visually represents (1) the government, (2) the technological-scientific structure, and (3) the productive structure as vertices of a triangle, where the government is placed at the top and stimulates interactions between the other two vertices at the base (Plonski, 1995; Noveli and Segatto, 2012). Sabato and Botana (1968, apud Plonski, 1995), proposed that nurturing the “intra-relations” (i.e., the relations among components inside each vertex separately) is necessary but not sufficient to foster social development, and that the “inter-relations” (i.e., between the vertices) would be the most interesting aspect to be explored. The visual representation of a triangle helps in exposing that the “horizontal relations”, lying at the base of the triangle (between the scientific and productive structures) are the fundamental relations, but also the hardest to establish (Plonski, 1995).

Leydesdorff and Etzkowitz (1995) argued that the interaction between universities and the industry, until relatively recently, “was based on a linear model of innovation, presuming only long-term contributions of academic knowledge to the economy” (p. 2). Over time, there was a “heightened and novel appreciation for the

importance of basic academic research to industry” (Etzkowitz, 1983, p. 198). Cohen, Nelson, and Walsh (2002) also acknowledge a “deepening of ties between public research institutions — particularly universities — and industry” (p. 3). Mowery et al. (2001) also observed that “although university–industry research collaboration has a long history, recent changes in the character of this relationship [...] have attracted considerable attention” (p. 99). Leydesdorff and Etzkowitz (1995) argue that “universities and industry, up to now relatively separate and distinct institutional spheres, are assuming tasks that were formerly largely the province of the other” (p. 1), referring to the development of basic and applied research, as well as innovation. In this sense, the linear model of long term flow of academic knowledge to the industry is now being replaced by a non-linear model where both long and short term contributions are possible, demanding a “spiral model of innovation [...] to capture multiple reciprocal linkages” (p. 2), inspiring the Triple Helix model.

The Triple Helix not only postulates that interactions between government, universities and the productive sector are essential (akin to the Sabato Triangle), but also that the dynamics of a well-developed innovation network involves some level of intersection of roles between all three dimensions and “hybrid organizations emerging at the interfaces” (Etzkowitz and Leydesdorff, 2000, p. 111), as graphically represented below:

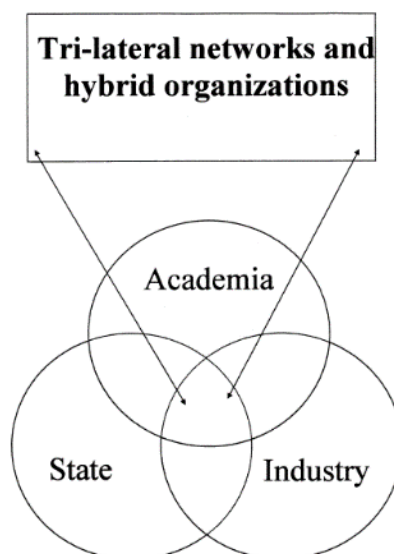


Figure 1 – Triple Helix Model
Source: Etzkowitz and Leydesdorff (2000, p. 111)

In contrast to the Sabato Triangle, the Triple Helix assumes, thus, a less fixed position, by acknowledging not only the interactions, but also the intersection of roles between the components of the model. Etzkowitz and Leydesdorff (2000) emphasize this intersection of roles by claiming that the Triple Helix model “is generating a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces” (p. 111). According to Ranga and Etzkowitz (2013), the Triple Helix perspective would be able to:

“help accelerate the transition from the low-risk, low-gain development model that is currently in place in many regions and countries and is conducive to slow, incremental innovation patterns with low economic returns, to a higher-risk, higher-gain development model that could favour more radical innovations and the accelerated creation of new markets, new growth opportunities, new jobs and new skills.” (Ranga and Etzkowitz, 2013, p. 257)

In summary, holding strong capabilities for technological innovation has been widely considered fundamental to socio-economic development of regions and countries. Continuous interaction between the academia and the private sector is regarded as a great enabler of innovation, and governments are considered essential in the process of promoting such interactions. In this context, diverse tools have been conceptualized regarding university-industry interactions, a brief overview of which will be provided next.

2.1.3 Academic Entrepreneurship

Articulations between universities and the productive sector - from the perspective of the first -, are sometimes studied under the general realm of “Entrepreneurial universities”. According to Readings (1996 apud Etzkowitz et al., 2000, p. 313), the university “encompasses a ‘third-mission’ of economic development in addition to research and teaching”. Etzkowitz and Leydesdorff (2000) call this a “second academic revolution” (p. 110), following what Jencks and Riesman (1968 apud Etzkowitz, 1998, p. 315) called the first academic revolution - the incorporation of research by universities, in addition to teaching, as a second mission.

“The increased salience of knowledge and research to economic development has opened up a third mission: the role of the university in economic development. A ‘second academic revolution’ seems under way since World War II, but more visibly since the end of the Cold War” (Etzkowitz and Leydesdorff, 2000, p. 110)

In Europe, Geuna (2001) has identified that pressure for more funding was one of the drivers of a “stronger market-orientation for higher education systems” (para. 6). In the U.S., Etzkowitz (1998) also found the same driver, claiming that “as research decentralises to a broader range of universities, including some that were not heretofore known for their research strengths, competition among universities for funds increases” (p. 826). Although some authors such as Etzkowitz (1998) might eventually frame the Entrepreneurial University motives as profit-seeking, for instance, when claiming that “the norms of science which traditionally condemn profit-making motives are beginning to change to allow for such a kind of entrepreneurship” (p. 824), the tendency of the literature is to frame profit not as an end, but as a means to achieve the goal of helping local social and economic development. This is clear in Dalmarco, Hulsink, and Blois (2018) when they present that “the entrepreneurial university has three basic pillars: education, research and socio-economic development” (p. 102), and Etzkowitz et al. (2000) have framed financial objectives as secondary, when claiming that “Entrepreneurial activities are undertaken with the objective of improving regional or national economic performance as well as the university's financial advantage and that of its faculty” (p. 313). Etzkowitz (1983, 1998) has highlighted the perspective of financial returns resulting from entrepreneurial activities in universities as not being the end in itself, but a means to other ends. By analysing interviews made with academics from the U.S., he noted that “scientists often say that monies made from commercialising their research will be applied to furthering their basic research interests” (Etzkowitz, 1998, p. 827).

Dalmarco, Hulsink, and Blois (2018) propose that the rise of entrepreneurial universities can be described in terms of “waves” (p. 100). The first wave happened in the U.S., beginning in the 1920s and is still evolving today, and among the pioneers are the MIT, Stanford, and the University of Wisconsin. The second wave happened in Western Europe from the early 1990s, and the third wave is happening in Eastern Europe, Asia, and South America.

Wood (2011) notes that “the idea of entrepreneurial universities has become embodied in a more focused concept called ‘academic entrepreneurship’” (p. 153), citing O’Shea et al. (2004), who described it as an umbrella term encompassing “the efforts and activities that universities and their industry partners undertake in hopes of

commercializing the outcomes of faculty research” (O’Shea et al., 2004 apud Wood, 2011, p. 153).

2.1.4 Mechanisms of university-industry interactions

The flow of scientific knowledge from academia to the productive sector pertains to the field of Technology Transfer. Cohen, Nelson, and Walsh (2002) compiled a list of ten usual information flow channels through which knowledge goes from the academia to the industry. The identified channels were the following: (a) Publications/Reports, (b) Informal interaction, (c) Public meetings or conferences, (d) Contract research, (e) Consulting (f) Joint or cooperative ventures, (g) Patents, (f) Personnel exchange, (h) Licenses, and (i) Recently hired graduates. Showing that research publications was the most frequent channel of information flow according to U.S. manufacturing firms, they maintain “In most industries, patents and licenses are not nearly as important as other channels for conveying public research to industry” (p. 16), but are useful to a few specific industries only. In Brazil, Póvoa and Rapini (2010) have conducted a similar research, but instead of surveying R&D managers in companies, they have surveyed academic research groups to self-report on technology-transfer activities they had been involved with. The results support the findings of Cohen, Nelson, and Walsh (2002):

“the main channels were publications and reports, indicated by 70.4% of respondents. The other important channels were conversations (45.4%), training (43.9%), and consulting (42.4%). Only 14.1% of respondents pointed to the use of patents to transfer technology” (Póvoa and Rapini, 2010, p. 155)

Nevertheless, there is no question that patenting and licensing activities have enjoyed a spotlight in earlier studies of university-industry articulations. According to Póvoa and Rapini (2010) “the technology transfer literature has been considering the patent and its licensing as *the* transfer channel” (p. 149), and continue to alert us that “despite universities’ enthusiasm in technology transfer, it is necessary to recognize that patents are just one of the channels of technology transfer” (p. 150).

Patenting and licensing in the field of Technology Transfer is by itself an extensive topic in the literature. This review will not go into discussions of this topic, as the purpose of this review is to simply situate the context in which Technology Parks came into existence. Like patenting and licensing, Technology Parks are one of the

many tools that exist in the realm of university-industry interactions for technological innovation.

Going beyond patenting and licensing to successfully articulating relationships between academia and the private-sector, Wood (2011) points to the “launch of a completely new business, typically called a ‘spin-off’” (p. 157). The author cites Shane and Stuart (2002) to define spin-offs as “an entirely new business that is formed around the university’s innovation, and may be wholly owned by the university or created jointly with outside partners” (p. 158). According to Etzkowitz, Mello, and Almeida (2005), spin-offs can be developed through university business incubators:

“Incubation is part of a broader trend of devolution from bureaucratic and hierarchical organizations to knowledge-based networks and clusters. Incubation is fundamentally an educational process to train organizations in adequate functioning, whether the trainees are academics or persons without formal education. It involves an expansion of the academic educational mission from training individuals to educating organizations.” (Etzkowitz, Mello, and Almeida, 2005, p. 412)

Business incubators here arise as one example of the so-called hybrid organizations suggested to exist at the intersections of the Triple Helix model. Other examples of such hybrid organizations include: (a) regional and national associations of representatives of the academia, the private-sector, and the government. These can work on a number of goals such as proposing new policies and networking its members; (b) some types of Venture Capital firms, which can be grounded on the proposition of interactions with universities and research institutes as one of their main pillars (Etzkowitz, Comez, and Zhou, 2009); (c) social and worker’s co-op incubators; (d) Technology Parks, among others.

In summary, there are multiple ways in which knowledge can flow from the academia into the private-sector for the purpose of technological innovation, in this context, Technology Parks are situated as but one of the many ways in which articulations between these two “helices” come to pass.

2.2 A brief overview on Technology Parks

The concept of a Technology Park “refers to enterprises implanted in large public or private areas, having scientific and technological entities inside them - universities and research institutes - becoming a center for Research, Development, and Innovation of private companies.” (Steiner, Cassim, and Robazzi, 2008, p. 9).

Technology Parks perform functions of support and integration between companies and between universities and the industry (Vedovello, Judice, and Maculan, 2006). These later authors note that Technology Parks have been given the role of “acting as a mechanism for spurring higher regional/local competitiveness and business performance” (p. 104).

In Brazil, Vedovello, Judice, and Maculan (2006) have found “a certain flexibilization in the conceptualization of technology parks” (p. 108). They highlight that across different countries the parks have adapted and evolved into many different concepts, and even within Brazil it was possible to recognize a multiplexity of concepts. Nevertheless, they propose that:

“regardless of the adopted concept, their main objectives are still: (1) job generation; (2) establishing new companies; (3) facilitating the interaction between universities and companies located within the parks, and (4) favouring the diffusion of new or high technology.” (Vedovello, Judice, and Maculan, 2006, p. 110)

Although different models exist, one of the most common traits of Technology Parks is the proposition to create synergies between academia and the private sector based on physical proximity, i.e., companies are physically hosted within a Technology Park that is attached to one (or more) local university and/or research institution. The expectation is that such physical proximity may sparkle both formal and informal interactions between companies and the scientific institution (Vedovello, 1997). Usually, Technology Parks will allocate personnel dedicated to active mediation and matchmaking of these two sides, not relying solely on physical proximity as sufficient to spark interactions.

The origin of the concept of Technology Parks is usually attributed to the development of the Silicon Valley, in California, and the Route 128, in Boston, between the 1940s and 1960s (Vedovello, Judice, and Maculan, 2006, p. 106). “The Silicon Valley phenomenon is the origin of the TP ideal” (Radošević and Myrzakhmet, 2009, p. 646), and its origin is directly related to the birth of the Stanford Research Park (SRP) in 1951.

There is not one single definition of a Technology Park in the literature. The definition put forward by the International Association of Technology Parks (IASP) regards Technology Parks as:

“...an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation

and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Technology Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services along with high quality space and facilities.” (IASP).

IASP also highlights that terms such as “Science Park”, “Research Park”, “Technology Park”, or “Science and Technology Park (STP)” are interchangeable within this definition. Indeed, the literature is fragmented with respect to the preferred terms to be used. Authors either provide their own definition of the selected term or refer to various sources, such as the IASP, regional associations of Technology Parks, or a specific Technology Park’s own definition of itself. For instance, Radosevic and Myrzakhmet (2009) employ the term “Technopark” (TP):

“The literature is cluttered with terms such as Technology Parks, business incubators, TPs and technopoles, organisational forms that are defined variously by different sources. Common to all these organisational forms is that they are property-related initiatives that aim to enhance knowledge clustering and networking among individual firms. We use the generic term ‘TP’, which is in common use in Kazakhstan [...]” (Radosevic and Myrzakhmet, 2009, p. 646).

The lack of a common definition and denomination for Technology Parks is likely due to the multiplicity of models adopted globally, which vary highly even inside a specific country or region. According to Vedovello, Judice, and Maculan (2006, p. 113), “Both in the global and the Brazilian contexts there is not a single concept of technological parks applied broadly and universally. As stressed before, this concept, in fact, does not exist. As there is also not a Brazilian model for technological parks”. In the Brazilian context, more recently, we can refer to the definitions set forth by the National Association for Entities Promoting Innovative Enterprises (Anprotec), and the Federal Law No. 13.243 of 2016 (which regulates aspects of the Brazilian Innovation System), which show a level of convergence:

(a) Anprotec: “The Technology Parks constitute a science-technology based complex of industrial production and services. Planned, formal, concentrated, and cooperative, aggregating enterprises whose production is based on R&D. The Parks act as promoters of a culture of innovation, competitiveness, and entrepreneurial capacitation, founded upon the transfer of knowledge and technology, aiming at increasing the production levels and wealth of a specific

region.”

(b) Federal Law No 13.243: “Technological Park: a complex for enterprise and technology development, promoting the culture of innovation, industrial competitiveness, entrepreneurial capacitation, and synergies between the activities of scientific research, technological development, and innovation, among companies and one or more ICTs [Science and Technology Institutions] with or without ties between them.”

2.2.1 Generations

The Brazilian Association for Industrial Development (ABDI), along with the Brazilian National Association of Entities Promoting Innovation Enterprises (Anprotec), released a Study in 2008 titled *Parques Tecnológicos no Brasil* (“Technological Parks in Brazil”), where three generations of Technology Parks have been categorized:

First Generation - “Pioneer Parks”: Such as the Stanford Research Park (which originated the Silicon Valley), characterized by (a) a spontaneous/natural development, rather than planned and modelled, (b) coming to life in regions with very favourable environments for developing new enterprises (entrepreneurial culture, access to high quality human resources and financing, high quality infra-structures, etc), (b) built in proximity to universities and/or research institutions with the aim to enhance the connection between them and private enterprises, and (c) generally had government led investments and incentives during their early development. For instance, expenditures of the U.S. Department of Defence on research was a main catalyst of Silicon Valley’s development (Koh, Koh, and Tschang, 2005, p. 226).

Second Generation - “Follower Parks”: These were formally planned and structured with the aim of replicating the success of first-generation parks. Generally supported by the government in hopes of bringing value to the regions associated with universities and to create technology poles. The second generation spread fast throughout developed countries in North America and Europe during the 1970s-1990s period.

Third Generation - “Structuring Parks”: Created in developing countries as part of a broader set of government policies with the aim to promote high-impact tools for socio-economic development. As such, these are also formally planned and structured,

with high levels of government investment. Since these are built with the aim of helping the economic development of a country, there should be tight links between the Technology Park's model with a bigger regional or national development strategy.

Vedovello, Judice, and Maculan (2006), subdivide the study of Technology Parks into two phases: “(1) an initial 'historic' phase (from the 1960s to around the 1990s), marked by a somewhat naive optimism and experimentations around the instrument [of Technology Parks]” (p. 105) and “(2) a 'contemporaneous' phase (second half of the 1990s to present), marked by a higher pragmatism and a relative scepticism about the effectiveness of the instrument (...)” (p. 105). According to the authors, the results and impact generated by later Technology Parks were generally assessed as modest. This is also present in ABDI's 2008 study, which highlights that the results of the second generation of Technology Parks are usually taken as modest. (Anprotec, 2008, p. 9).

In developing countries, where parks are usually part of the third generation (Anprotec, 2008, p. 9), the newness of these institutions is still a complicating factor in evaluating their performance in relation to socio-economic development goals. In Brazil, for instance, Abreu et al. (2016) highlight that “parks are structures still very recent in the Brazilian innovation system. Since their maturing is long-term, it is still hard to measure the results of their operations.” (p. 121). Notwithstanding this, there have been attempts to assess the parks. De Araújo Junior (2016), for example, has evaluated the Technology Park of the Federal University of Rio de Janeiro through a network theory lens, and concluded that the results of the park in terms of bringing competitiveness and economic development to the region were modest.

2.2.2 Multiplicity of models and performance

There is no homogeneity in models of Technology Parks adopted globally, and even inside a specific region or country (Vedovello, Judice, and Maculan, 2006). The models vary in many dimensions, for example: sectors of resident/associated companies (parks may have specific sectors they are focused on or be general); size of companies (some may be directed towards small and medium enterprises, some towards large companies, or both); number of scientific institutions they are associated with (some may be created to promote interactions with a single university/research

institution, some may not); legal form (some may be government entities, others may have private juridical forms), among many other things. Not even the focus on technology-intensive enterprises can be taken as uniform across Technology Park models, as Phan, Siegel, and Wright (2005, p. 177) note “not all Technology Parks and incubators focus exclusively on promoting technology intensive firms.”. Furthermore:

“the types of R&D conducted and the sectors they focus on vary. Some Technology Parks and technology districts are focused on basic research (e.g., the Cambridge Technology Park), while others are focused on applied research (e.g., the SSP [Singapore Technology Park]). There are also Technology Parks and technology districts that possess strong manufacturing capabilities, either within the park itself or in its vicinity (e.g., the Hsinchu Technology District in Taiwan)”. (Koh, Koh, and Tschang, 2005, p. 220)

Phan, Siegel, and Wright (2005), and Vedovello, Judice, and Maculan (2006, p. 107) reckon that the diversity of models utilized, and the idiosyncrasies present in the environment in which each Technology Park is inserted, result in difficulties in establishing general performance measures for Technology Parks.

“Perhaps no general theory is possible because the causes and consequences of Technology Parks and incubators may be idiosyncratic to their geographic locations, political and social contexts, and economic systems. However, to make such a conclusion at this time would probably represent a rush to judgment on very thin evidence” (Phan, Siegel, and Wright, 2005, p. 170)

Performance of companies associated with Technology Parks is one common indicator which, at times, is used as a proxy to assess the performance of the Technology Park itself. Bigliard et al. (2006, apud Vedovello, Judice, and Maculan, 2006), suggest that the performance of companies inside Technology Parks and the performance of the Technology Parks themselves should be separated. According to them, Technology Parks should be measured according to their own development strategies and specific objectives, instead of the traditional focus on the performance of tenant firms or other general indicators. These specific objectives should translate the mission statement set forth by each Technology Park individually. This is corroborated by Phan, Siegel, and Wright (2005), which observed that many studies use longevity of tenant firms as a dependent variable in evaluating performance:

“Survival is a particularly problematical measure given the different objectives of the various types of Technology Parks and incubators. There is therefore a need to take into account the interaction between objectives and the nature of performance. Associated with this observation is the need to undertake further theoretical explication on the use of longevity or tenure as a dependent variable.” (Phan, Siegel, and Wright, 2005, p. 167)

This is to exemplify that the problem of performance is not simply one of measurement, but, more fundamentally, it is one of defining and conceptualizing which are the relevant dimensions and variables to be taken into consideration.

Technology Parks of the third generation in developing countries might commonly be benchmarked against the first generation of parks (Koh, Koh, and Tschang, 2005, p. 222). As stressed by Radosevic and Myrzakhmet (2009) it may be hard to differentiate what problems can be attributed to the models of Technology Park themselves, or simply to the overall economic problems of the region:

“The preconditions for technology-based competition are undeveloped in emerging economies and TPs [Technoparks] are seen as organisations that could compensate for missing markets, interactions and skills. In this respect, the problems related to TP in emerging economies are, de facto, the old problems of economic backwardness as analysed by Gerschenkron (1962).” (p. 645)

In this sense, the eventual poor or modest performance of a Technology Park in a developing country (especially if compared to the first generation of parks) may not necessarily reflect a problem with the model utilized by the Technology Park itself, or with the entire concept of Technology Parks. It simply indicates that the environment does not provide the Technology Park with adequate demand and services related to Research, Development and Innovation (R&D&I).

Koh, Koh, and Tschang (2005) proposed that one of the fundamental indicators is a transition from government-led growth to private-led growth. While it is possible that Technology Parks can continue to survive indefinitely with the aid of government investments, and governments are expected to play a critical role for Technology Parks to come into life, a long-term existence on life-support from the government is generally not considered ideal for Technology Parks. Instead, governments should focus on funding specific R&D&I projects and Human Resources to work on innovation environments (Radosevic and Myrzakhmet, 2003). In this light, government investments are not expected to vanish from Technology Parks, but Technology Parks are expected to transition into being primarily led by sources other than public funding for their direct management and basic infrastructure. This point may perhaps indicate a difference between assessing Technology Parks in terms of performance indicators related to economic and social impact, such as the performance of resident companies, jobs created, volume of formal links between companies and a scientific institution established within the park, patents issued, and more (e.g., as in Guy, 1996; Hogan,

1996; Staton, 1996; UKPSA, 2003; Monck and Peters, 2009), and the managerial challenges for organizational continued existence.

2.3 Archetypes of organizational success and failure and the five challenges of growth

Fleck (2009) conducted a longitudinal study of General Electric and Westinghouse, collecting data regarding (a) the inner workings of the organizations, (b) environmental conditions they operated in and (c) the interface between these two components. This study was motivated by the observation that “more often than not, today’s widely praised corporate success stories become tomorrow’s highly criticized nightmares” (p. 79). The question of why some companies thrive while others fail even under greatly similar environments poses a remarkably interesting topic to be studied by management scholars, and this study sought to shed more light into the subject.

The author proposed that process theory could yield more meaningful insights into the question, seeking to identify necessary but not sufficient conditions for an organization’s continued, healthy, existence and growth (Chandler, 1977), as opposed to a causality approach. By doing so, the longitudinal study converged into five categories of challenges related to growth. The analysis of responses to these challenges can provide a picture of an organization’s ability to self-perpetuate or self-destruct.

Fleck (2009) has condensed the analysis of the challenges into two archetypes of organizational success and failure, by attributing adequate versus inadequate responses to every challenge. These are the self-perpetuating and the self-destructive archetypes, and are rationalized through the interactions and feedback loops between the five challenges. The self-perpetuating propensity is further explained in terms of organizational renewal and integrity.

It is worth noticing that the growth notion should not be reduced to quantitative indicators, such as profit growth, nor measures of physical or geographical size. According to Fleck (2018), in addition to quantitative aspects, the growth notion includes both qualitative elements and viewing growth as a process of change. Regarding the organization notion, for the purpose of analysis of a focal entity with the help of Fleck’s (2009) model, internal parts of larger organizations can still be

considered organizations in and out of themselves, provided there is sufficient distinction to encapsulate them (e.g., a Technology Park that is part of a large university could still be the focus of analysis, as opposed to the entire university).

In Table 1, next, Fleck's summary of each challenge as well as the responses for each archetype will be provided. A detailed discussion for each of the five challenges will follow through sections 2.3.1 to 2.3.5

Table 1 – Archetypes of organizational success and failure

Challenge Category	Challenge Description	Polar Responses to Challenge	
		Self-destructive	Self-perpetuating
Enterprising	Promoting continued entrepreneurship by fostering the firm's willingness to carry out reinforcing, value-creating expansion while also preventing the organization's overexposure to risk	Satisficing or less (Low level of ambition, versatility, imagination, vision, fund-raising, ingenuity, and judgment, using nil- & defensive-motivated moves)	High-reaching (High level of ambition, versatility, imagination, vision, fund-raising, ingenuity, and judgment, using productive- & hybrid-motivated moves)
Navigating into the Dynamic Environment	Dealing with the organization's multiple stakeholders in order to secure value capture and organizational legitimacy	Drifting (Poor scanning, untimely or inadequate use of response strategies*) *These are: manipulation, defiance, avoidance, acquiescence, compromise	Fashioning (Regular scanning, timely and adequate use of response strategies*)
Diversity Management	Sustaining the firm's integrity in the face of increasing organizational conflicts and rivalry	Fragmentation (Failure to establish, bonding relations and, coordinating, capabilities)	Integration (Successful development of bonding relations and coordinating capabilities)
Managerial Resources Provisioning	Steadily equipping the firm with necessary qualified human resources	Late (Just-in-time or, after the fact actions)	Early (Planned in advance actions)
Complexity Management	Managing complex issues and solving problems of increasing complexity so as to avoid risks to the organization's existence	Ad Hoc (Poor problem solving capabilities upholding quick search for solutions and precluding learning)	Systematic (Strong problem solving capabilities promoting comprehensive search for solutions and fostering learning)

Source: Fleck (2009, p. 85)

2.3.1 The challenge of enterprising

Penrose (1959) differentiates managerial and entrepreneurial services available to an organization. While managerial services concentrate on keeping the daily operations in motion – the already established activities – and carrying out ideas set by entrepreneurial services, entrepreneurial services are the source of planning and moving in the direction of growth, envisioning opportunities available from resources within the organization with a nexus to external circumstances.

Entrepreneurial services constitute the key ingredient for growth, effectively putting a limit to the amount of expansion an organization will be able to undertake over time. While in practice both managerial and entrepreneurial services can be commonly provided by the same individual, at varying degrees, a conceptual differentiation between them is a basic ground to understand growth. The first consideration here is to acknowledge that entrepreneurial services are multidimensional, where the most critical areas involve skills related to: ambition, fund-raising ingenuity, judgement, and versatility (Penrose, 1959; Fleck, 2009). A second consideration is that high skilled entrepreneurial services are not uniformly distributed among organizations, therefore one can envision a situation in which some organizations display high levels of entrepreneurial services, while others might exhibit poor levels of it in some or all of the aforementioned dimensions (Fleck, 2009).

Ambition is a driving force condensed in the willingness to expand and evolve either the current set of activities or new envisioned venues for growth, in the absence of which, growth will not materialize. Regarding this, Penrose (1959) sets an important distinction between two types of entrepreneurs, the “workmanship-minded” and the “empire-builder”. The workmanship-minded entrepreneur is oriented to building upon the same organization, improving and expanding its current activities and markets, while looking for new markets in which the resources available to the organization are believed to provide some kind of an advantage. The empire-builder, on the other hand, will tend to constitute a set of organizations that are not effectively linked under an encompassing management structure. This last element – an integrated management structure – is a defining character of organizational identity suitable for the analysis of growth. As differentiated, for instance, from purely financial holding companies, where

a link between managerial structures of the organizations might not exist (Penrose, 1959).

Fund-raising ingenuity is the entrepreneurial ability to acquire external sources of financing to undertake growth. Penrose (1959) argues that both small and big organizations incur challenges in this regard, and even under similar markets and general circumstances, one could observe different outcomes in this dimension, suggesting that fund-raising is linked to entrepreneurial abilities. And “only if the requisite entrepreneurial ability is lacking can one safely say that a firm cannot attract the required capital” (Penrose, 1959, p. 34), as such, difficulties to undertake growth are often directly related to a lack of financial resources by observers, but this direct relationship overlooks the fact that the lack of financial resources “may often be just as well attributed to a lack of entrepreneurial services” (Penrose, 1959, p. 35). Furthermore, this dimension of entrepreneurial services might be as closely related to the other dimensions, being greatly linked to the personal ability in generating trust.

Versatility is the imaginative, visionary, and experimenting dimension of entrepreneurial services. This is an ability to, above all, envision new pathways for growth, diverging from current and past activities, which often leads to new products, new services and new markets to be explored. This entrepreneurial service should have a balance to not render impractical ideas, while still moving away from commonplace and short-sighted attempts (Penrose, 1959).

Judgement is related to the ability to render a solid interpretation of risks, both internal and external, involved on a given planned growth. This is partly dependent upon the entrepreneurial subjective picture of the environment and of the internal resources at hand - through personal abilities such as good-sense and self-confidence -, but also greatly dependent upon the organizations’ internal tools for effective and reliable collection and spread of information.

Risk taking constitutes a necessary condition for growth, and is related to the completeness of information gathered by the organization, as well as the entrepreneur’s subjective interpretation of it - its judgement ability. “As planning proceeds, the point will be reached where a firm believes it is either impossible or too expensive to attempt to obtain further information” (Penrose, 1959, p. 54), thus, a level of risk taking is inherent to expanding moves. Balancing the level of risks while still expanding constitutes a key challenge related to entrepreneurial services. “Enterprise

and attitude towards risk are, in this context, opposite sides of the same coin, for enterprise includes the willingness to take risks. But [...] it also includes the willingness to search for ways of avoiding risk and still expand” (Penrose, 1959, p. 56).

Enterprise services - interacting with the general resources available inside the organization and an interpretation of the external environment -, will then shape the type and direction of growth undertaken by organizations, as well as put a limit to the rate of expansion.

Regarding the types of expansion, Fleck (2009) points to the contributions of Alfred Chandler (1977), differentiating between Productive and Defensive expansion. While productive expansion is likely to produce the requirement for continuing growth, focusing on the development of economies of scale, scope, and/or speed, Defensive expansion seeks to maintain the established position of dominance in a given market, the classical examples being vertical integration and horizontal acquisitions made to keep competition down. Fleck (2009) also proposes two additional types of expansion: Hybrid and Nil. Hybrid integrates Productive and Defensive motives, and “allow a firm to improve its efficiency and protect existing businesses” (Fleck, 2009, p. 86), while Nil drives the empire-building entrepreneur mentioned earlier in this section (Penrose, 1959). A second important dimension is related to Exploitative and Explorative expansion (March, 1991 apud Fleck, 2010), i.e., expanding in current activities versus expanding into novel markets (versatility) – both directions having its pros and cons.

The challenges related to entrepreneurial activities are, thus, linked to the process of value creation (Lepak, Smith, and Taylor, 2007; Fleck, 2009). As these later authors point out, entrepreneurship studies often analyse the creation of value at an organizational level (p. 181).

2.3.2 The challenge of navigating into the environment

According to Fleck (2009; 2010), navigating the environment is complementary to the Enterprise challenge in two ways, first, while the Entrepreneurial challenge is mostly concerned with value-creation, the navigation challenge is related to value-capture (Lepak, Smith, and Taylor, 2007). Second, while the entrepreneurial challenge is mostly concerned with market forces, “the navigating challenge essentially copes with nonmarket pressures” (Fleck, 2010, p. 1532).

The value-capture is sought in two ways: (a) by having an active role in shaping the environment, as to secure and maximize the organization's ability to capture value from its value-producing activities. This challenge can be related to the concept of "value slippage", as exposed by Lepak, Smith, and Taylor (2007), "when the party creating the value does not retain all the new value that is created" (p. 187), stressing that it may move across the levels of analysis, so slippage of value produced by organizations may move up or down to the levels of society and the individual entrepreneurs (p. 190). And (b) "the organization strives to capture normative value by means of acquiring and sustaining organizational legitimacy" (Fleck, 2010, p. 1532).

One piece of the puzzle to further understand the challenges regarding the first of those – active role in shaping the environment – can be found by looking at the interaction of the two drivers of growth proposed by Fleck (2003), the continuous growth driver and the co-evolution driver. The first of those – that of continuous-growth - draws on the ideas of Chandler (1977) and Penrose (1959), and is related to the quest of maximizing continuous and profitable utilization of resources available to a firm, whereby underutilized resources evoke a disequilibrium. Recognizing opportunities to more efficiently utilize services available from internal resources creates room for further growth, and the expansion itself tends to produce further levels of disequilibrium. The second driver – that of co-evolution -, recognizes the conjoint growth of organizations and the industries they operate in, whereby the growth of an industry constitutes a necessary - although not sufficient - condition for the growth of the organization. Furthermore, the growth of an industry commonly goes through a process of standardization - a necessary condition for the growth of the industry -, that is achieved through a cooperation between organizations operating inside the industry. The interaction between the two dimensions is shown by the author in the figure below, exemplified for the early developments in the industry of microcomputers:

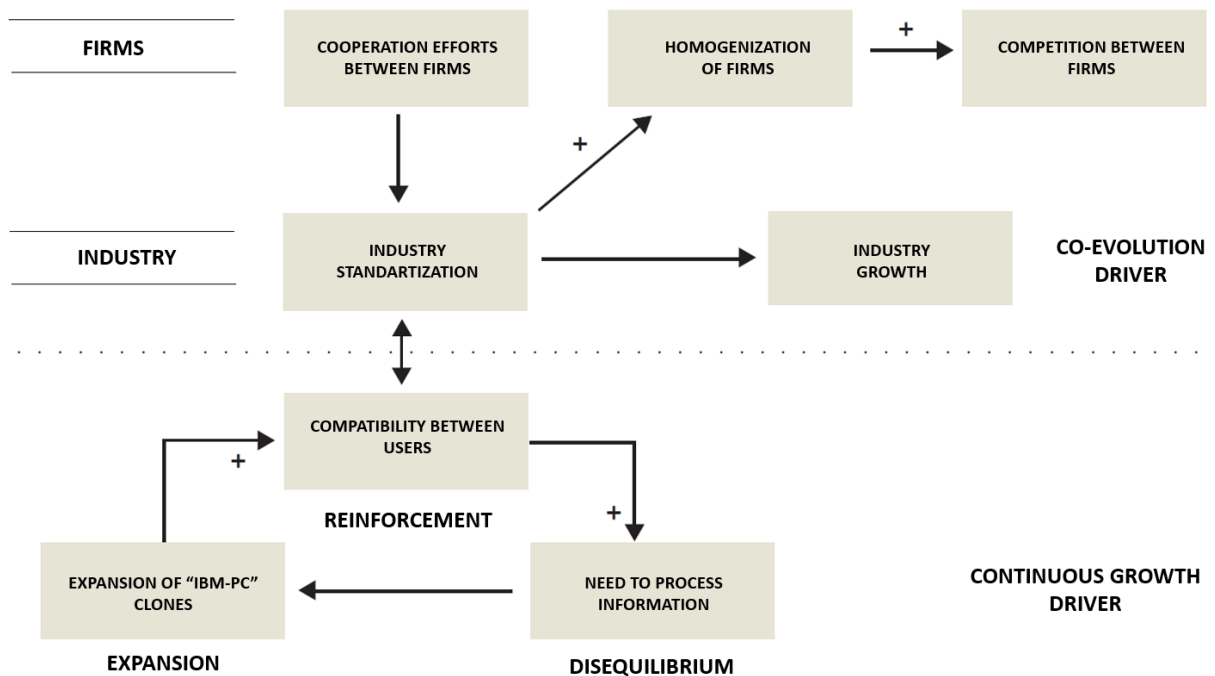


Figure 2 – Two Drivers of Growth
Source: Adapted from Fleck (2003)

This provides a good exposition of the role performed by organizations in their environment.

Another dimension can be observed in the challenges related to institutionalization. Fleck (2007) starts by recognizing two streams of institutionalism, Old Institutionalism (OI) and New Institutionalism (NI). The first of those emphasizes the role of active management and leadership in infusing identity into organizations, the second stream emphasises the role of field homogenization, as observed, for instance, in DiMaggio and Powell's (1983) proposal of Institutional Isomorphism. "Both the old and new streams put forward a counter-intuitive notion: that institutionalization processes increase chances of survival while reducing efficiency" (Fleck, 2007, p. 66), this is related to a positive link between institutionalization leading to organizational rigidity, and rigidity posing disadvantages specially in regards to responding and adapting to environmental conditions and anticipated changes. Furthermore, OI, with its active agency focus, plays a major role during early stages of organizational character formation, on the other hand, NI plays a major role in "the stable phase of organizational and field existences" (p. 69). Fleck (2007) draws on Machado-da-Silva et al. (2005) to stress that both dimensions interact over time. In this interaction, both active management of organizations can shape the environment as well as the environment can shape organizational character traits.

In spite of the links between institutionalization to rigidity, potentially leading to slow or inappropriate responses to the environment, “factual evidence indicates that long-term success and institutionalization can coexist” (p. 76). This is much due to the aforementioned possibility of managerial agency in shaping the environment. In this line, Fleck (2007) proposes two modes of institutionalization, the proactive and the reactive modes.

In the active mode “agency plays a major role in organizational institutionalization, and in managing the organization’s relations with the environment” (p. 64), neutralizing negative effects of institutionalization. While, in the reactive mode, structure dominates over agency, paving the way to resistance to change.

Therefore, these considerations can also shine light to some of the challenges relating to navigating the environment, the reactive and proactive modes being different ways through which organizations face these challenges. Fleck (2010) cites Oliver and Holzinger (2008) to note that “responsible reaction to external pressures and trends consists of a repertoire of proactive and anticipatory responses rather than merely defensive and passive reactions” (p. 1533). Adopting more active types of response to institutional pressures in the terms defined by Oliver (1991) are deemed the adequate posture in light of this theoretical model.

Complementary to the modes of reacting to environmental conditions is the ability to properly scan the environment in order to draw unbiased and systematic analysis of both present and future pressures.

Attention to these two dimensions – scanning and reacting – can be useful in understanding that organizations might be able to accurately collect information and interpret the environment, but proper reactions to it, when requiring a change of direction, might still not even be pursued (as opposed to a failed attempt), indicating high levels of rigidity. This can be observed in the concept of “active inertia”, put forward by Sull (1999), defined as “an organization’s tendency to follow established patterns of behaviour — even in response to dramatic environmental shifts” (para. 3). To illustrate active inertia, the author provided some examples, one of which was Firestone, where the company was not taken by surprise regarding an important shift in its environment, but failed to adapt due to an attachment to its traditional ways.

Lastly, Fleck (2009) highlights a few considerations regarding the environment itself, which can be classified, according to specific areas or in general, as forgiving,

challenging or inhospitable, according to the easiness to create and/or capture value. “While a ‘forgiving’ environment would easily enable value creation and value capture, an ‘inhospitable’ one would preclude value creation and/or value capture, and a ‘challenging’ environment would neither preclude nor easily enable [it]” (p. 97).

The environment is subdivided into three dimensions: natural, institutional, and competitive. Conversely, the environment will be constituted from varied types of stakeholders, from which adequate responses can vary in quality. Theoretical work on stakeholders can be applied in order to aid analysis, such as Miles’ (2017) classification of stakeholders.

2.3.3 The challenge of managing diversity

Fleck (2010) notes that “a by-product of successful growth process is increased organizational diversity” (p. 1533). Organizational diversity materializes in multiple dimensions, as examples, organizations can be diverse in terms of markets, technologies, personnel, geographical locations, communication channels and inter organizational relationships, strategies and tactics, among others. The author draws on Page (2007), and DeLuca and McDowell (1992) to distinguish workforce, structural and business diversity (p. 1533).

Fleck (2009) also notes that “heterogeneity among the constituent parts of the organization gives rise to conflicts and rivalry” (p. 86), therefore, integrating and coordinating diversity within organizations constitutes a fundamental challenge for the management of growth.

Fleck (2010) highlights that organizations may fall into two easy pathways to deal with diversity, both of which might pose significant threats for organizational health over time. The first of which involves “weakly-coordinated autonomy of its parts and abstains from promoting interunit exchange” (p. 1533). The second way leads the organization towards becoming a simpler entity (Miller, 1993, apud Fleck, 2010). This involves standardization and concentration on specific, or a reduced range of, skills, departments, and strategies. As stressed by Fleck (2010), these responses to diversity can be dangerous in emphasising speed over more important considerations in the process of growth.

Well-managed diversity requires an active recognition of heterogeneous and homogeneous elements and fomenting “suitable bonding relations” (Fleck, 2009, p. 86). These relations, in turn, require the setting up of appropriate coordination mechanisms, “such as liaison positions, task forces, standing committees, integrating managers and integrating departments” (p. 87). Homogeneous elements can be bonded through resource sharing, while heterogeneous elements can be bonded through resource exchange and/or combining (p. 86). Sharing can give rise to economies of scale, scope, and speed, involving shared tangible and intangible resources such as facilities, personnel, reputation and myths. While exchanging and combining can be done around tangible resources and organizational processes, building strong and complex relationships among otherwise heterogeneous elements of the organization (p. 87).

2.3.4 The challenge of provisioning human resources

Managerial human resources are central to ensuring the continued existence of organizations, as well as operating successful growth. Fleck (2001) observes that the constitution of management hierarchies (Chandler, 1977) “was a necessary condition for the firm to profitably perform administrative coordination” (p. 20). The hierarchies of professional managers allow for continued existence, as the organization develops an ability to out-live its members. While the profitable managerial coordination, therefore enabled, “gives rise to the continuing growth process” (p. 24).

According to Penrose (1959), managerial resources render services essential for growth. As previously stated, managerial personnel can render Entrepreneurial and Managerial services, both may or may not offered by the same individual. Entrepreneurial services are related to the dimensions discussed in the section “The challenges of enterprise”, encompassing ambition, fund-raising, versatility, and judgement. Managerial services relate to “the execution of entrepreneurial ideas and proposals and to the supervision of existing operations” (p. 29, footnote). Both types of service are required for growth (Fleck, 2010).

The level of availability of these services effectively limits the amount of growth an organization will be able to undertake at a specific time. Managerial services able to undertake growth processes are absorbed during each growth project, limiting the

rate of growth due to this absorption. Furthermore, these resources may also be absorbed by the operation of current activities, in the cases where there is not an exclusive dedication to growth activities (Penrose, 1959).

Managerial and entrepreneurial services effectively limit the rate of growth because they cannot be purchased on-demand over the marketplace. As noted by Penrose (1959) “an administrative group is something more than a collection of individuals; it is a collection of individuals who have had experience in working together” (p. 41), it is a team, and successful cooperation between individuals requires trust, which takes time to be built. Experience in working together enables managerial resources to offer “uniquely valuable” (p. 42) services to the organization, thus “the process by which experience is gained is properly treated as a process creating new productive services available to the firm” (p. 43). However, to gain work experience together, there should be demand for their services inside the organization – to be performed alongside previously existing managerial resources -, this, in turn, implies a limit to the creation of these services, even when there is high availability of human resources outside the firm to be hired, for there is a limit to the amount of resources that can be properly integrated into actual team work experience over growth-related processes.

In addition to managerial personnel, proper provision and maintenance of human resources in general is also essential to keep a healthy organization. Personnel contracted on a long-term basis can be viewed as durable resources, and “the firm suffers a loss akin to a capital loss when such employees leave the firm at the height of their abilities” (Penrose, 1959, p. 22). Moreover, Fleck (2010) draws on an extensive literature to stress dysfunctions that may arise due to oversized and undersized (overworked) staff, as well as a mismatch between personal skills and attributed tasks.

As such, this challenge “deals with steadily equipping the firm with needed qualified human resources, i.e., anticipating needs, forming, retaining, developing and renewing these resources” (Fleck, 2009, p. 87), and organizations may display tendencies for early or late responses to the challenge, where late responses negatively impact organizational integrity (p. 87).

2.3.5 The challenge of managing complexity

Complexity arises out of an increased number of variables and increased relationship links between those variables that can, in fact, be relevant for decision making and problem solving. According to Fleck (2009), as an organization grows, the more complex it is likely to become. Increased complexity will be evident in all challenges mentioned in this section: the way an organization manages complexity will impact the outcomes of its enterprising activities, navigation of the environment, diversity management, and human resources provision. Adequate response to complex problems “requires systematic procedures of data gathering, analysis, decision-making and implementation” (Fleck, 2009, p. 87).

Where Ad Hoc problem solving looks for easy and quick ways to get around challenges, it “precludes learning” and threatens the overall health of an organization. Therefore, implementing systematic approaches to analyse complex variables and their relationships, providing a solid ground for decision making, can contribute and allow an organization’s continued existence and growth by facilitating adequate responses to the previous four challenges presented in this section.

2.3.6 Interactions, feedback loops, and self-perpetuation

The five challenges described above constitute a variance model when accounting for the interactions and feedback loops between them, which in turn affect organizational renewal and integrity, both necessary conditions to achieve and maintain a self-perpetuating propensity. The interactions are shown in the figure that follows next, and a brief explanation will be provided.

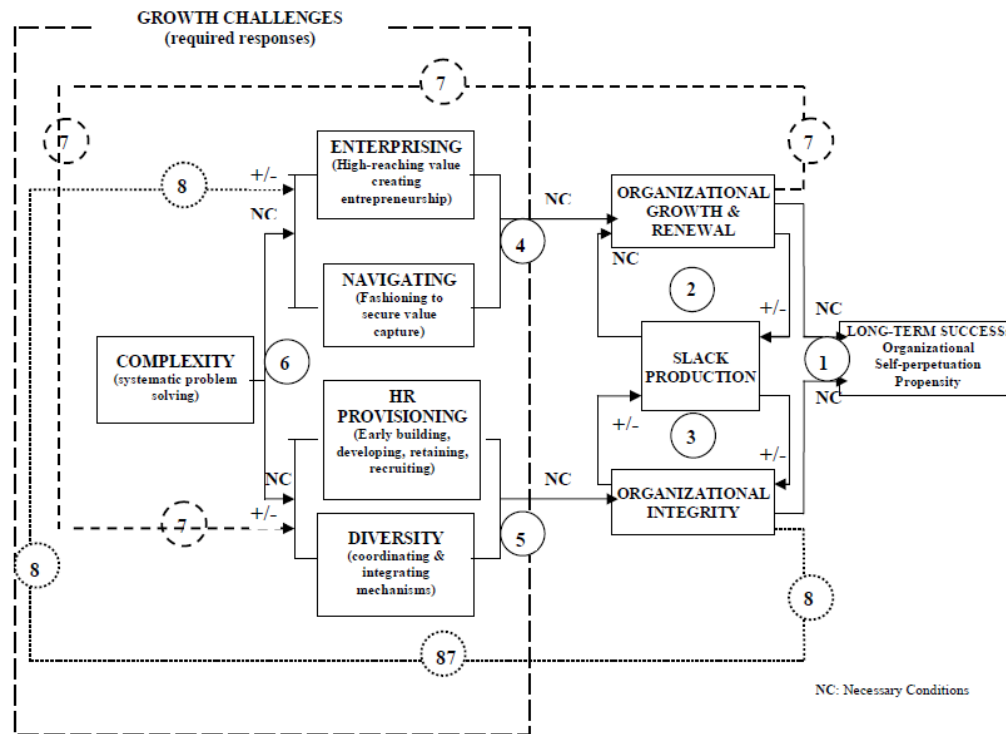


Figure 3 – Model of requisites for developing organizational self-perpetuation propensity
Source: Fleck (2009, p. 90)

Managing complexity is positively related to the remaining four challenges, as mentioned above, when Ad Hoc problem solving is predominant, “sooner or later the firm will face overexposure to business risk, leave unattended organizational legitimacy threats, fail to provision qualified human resources and fail to neutralize the pressures towards fragmentation” (p. 93). A systematic approach to problem solving will require the ability to learn from past experiences, for instance, through a knowledge database and systematic ways of collecting data.

Organizational renewal through growth is derived from Penrose (1959) and Chandler (1977), and is related to the quest of maximizing continuous and profitable utilization of resources available to a firm, whereby underutilized resources evoke a disequilibrium. Recognizing opportunities to more efficiently utilize services available from internal resources creates room for further growth, and the expansion itself tends to produce further levels of disequilibrium - as mentioned before when briefly discussing the two drivers of growth (Fleck, 2003). Both the Enterprising and the Navigating challenges are necessary to set this in motion. First, as explained by Penrose (1959), Entrepreneurial services in the form presented above (ambition, judgement, versatility and fund-raising abilities) are the basis upon which organizations engage in “non-threatening reinforcing expansion” (Fleck, 2009, p. 92). Next, the way

an organization responds to the navigation challenge (scanning, shaping and neutralizing pressures), will impact its ability to capture value created through its growth.

Organizational integrity is necessary for self-perpetuation as the organization strives to prevent fragmentation of its parts. As highlighted by Fleck (2009) through multiple theoretical perspectives, pressures derived from growth may lead to self-destruction as its constituent parts drift apart, as observed, for instance, in agency theory, stakeholder theory, corporate ethics, and social responsibility (p. 91).

Both organizational integrity and renewal through growth are linked to slack generation, which consists of “all sorts of resources that exceed what is needed for the organization to operate at a given desired performance level. These resources include both hard and soft categories, such as people, equipment, capital/profits, brands, reputation, etc” (p. 91). The link to renewal is made clear by Penrose (1959) when noting that services are required to pre-exist before expansion takes place, both Enterprising services which are needed to plan and undertake growth, and general slack resources which provide the disequilibrium mentioned above (on a feedback loop). As for organizational integrity:

“Slack may positively influence organizational integrity when applied, for example, to develop and implement integrating and coordinating mechanisms. [...] Slack may, however, negatively affect organizational integrity. For one, slack may fuel political battles for resources. In addition, slack is likely to erode the organization’s values and character and promote organizational disintegration if it is heavily used to maintain the organizational coalition, and/or to compensate for inefficiency...” (p. 92).

Ultimately, both organizational renewal and integrity constitute the necessary conditions for long-term success (healthy existence), which in turn are affected by the five challenges presented herein. In order to provide an analytical power through the model, Fleck (2009) has therefore proposed the archetypes of success and failure as ideal modes of responding to these challenges. Furthermore, the author notes that these should likely be viewed as moving targets, as the organization grows, “the levels at which responses should be given necessarily change over time” (p. 97)

3 Method

3.1 Research approach

As exposed during the literature review, Phan, Siegel, and Wright (2005) observed a lack of any well-established specialized theory or model for the investigation of Technology Parks. Furthermore, Technology Parks display a great variety of models across countries and regions, while displaying multiple important levels of analysis (Phan, Siegel, and Wright, 2005; Vedovello, Judice, and Maculan, 2006; Anprotec, 2008). The literature on assessment of Technology Parks tends to place great emphasis on impact or performance measurements. However, we propose that an analysis in the light of strategic management (not necessarily pertaining to themes of innovation) is also relevant, because Technology Parks may cease to exist if growth-related managerial challenges are not properly addressed. In addition, continued failure to generate significant innovation and socio-economic impact will affect their legitimacy and relevance in society, which Fleck's (2009) navigating challenge and organizational integrity condition may indirectly capture.

Phan, Siegel, and Wright (2005) also advanced that "there are existing organizational theories that we can exploit" (p. 175) to generate models for the analysis of Technology Parks (as briefly exposed in the literature review). This work will take advantage of already existing organizational theory; however, it will not attempt to build a model for the analysis of Technology Parks. It will employ a previously developed model for the assessment of professionally managed organizations engaged in economic activities. The model is Fleck's (2009) archetypes of success and failure, already presented during the literature review section. The model engages in the analysis of challenges pertaining to the growth of organizations, and how they respond to these challenges might indicate patterns, which position them in a better- or worse-off condition to self-perpetuate. If we consider that Technology Parks are formal organizations engaged in economic activities that also undergo growth processes, these challenges constitute therefore an integrating part of their success.

The theoretical model to be applied calls for the collection of process data and environmental contextualization covering extended periods of time. The methodology of case studies (Yin, 2018) can therefore be the best route to perform this task provided that the object of study is contemporary. According to Yin (2018) case studies are adequate "the more that your questions require an extensive and 'in-depth description

of some social phenomenon” (p. 4), which is precisely the case for the type of analysis to be performed under the theoretical model applied in this work.

Furthermore, Yin (2018, p.9) notes that case studies are best fitting for research that does not require control over behavioural events and that focuses on contemporary events - “‘contemporary’ meaning a fluid rendition of the recent past and the present, not just the present” (p. 12). The research question to guide data collection and analysis is: **what challenges do Brazilian Technology Parks located in public universities face for fostering a healthy existence?** While the primary output of the work is the analysis of PTEC-UFRJ in terms of its responses to the challenges of growth (Fleck, 2009), a secondary objective is set at identifying management challenges that may be relevant for the planning and implementation of other Technology Parks in the country, as these naturally arise out of the primary analysis.

3.2 Selection of a Technology Park to be studied

After defining the initial scope of the project - that of investigating the challenges involved in the growth of Technology Parks in Brazil –, the next step was to find examples of those types of organizations active in the country.

According to Creswell (2013), “the idea behind qualitative research is to purposefully select participants or sites (or documents or visual material) that will best help the researcher understand the problem and the research question” (np.).

There is a considerable number of Technology Parks in Brazil, albeit all of them are relatively young, most being one to two decades old, or even less. Nevertheless, there are a handful of parks that have exhibited expressive and faster growth than others, in terms of the number of resident or associated companies, financial resources received both from the private and public sectors, number of jobs created, and other indicators (Refer to CDT/UNB, 2019). These would provide the most solid ground for research, as noticeable effects and challenges of growth have already been incurred to some extent, and can therefore be analysed.

The basic grounds considered to be of importance in order to yield a viable and detailed research were the following: (a) The park should have exhibited considerable growth during its lifetime, and still be active; (b) information regarding historic events

related to the park should be widely available through public documents, news outlets, and online sources; and (c) there should be no reasons to believe that direct contact to personnel, both current and past, would be highly unlikely.

Among those, which have exhibited notorious growth, the first identified example was the UFRJ Technology Park (PTEC-UFRJ), which experienced accelerated growth during the period 2010-2016. Other examples of parks that displayed considerable growth were: Tecnopuc, Porto Digital, The São José dos Campos Technology Park, CTI-TEC Unicamp, Serratec, among others.

The chosen park is TEC-UFRJ, a notorious example of a Technology Park in Brazil, that attracted much interest during its rapid expansion period from 2010 and 2016. In addition, considering the need for interviews with management personnel, the park was also regarded as potentially being the most accessible case, due to it being associated with the same university where this work was carried out. Finally, a search for publicly available data suggested that high amounts of information could be found and collected.

For several reasons, the PTEC-UFRJ constitutes a very interesting case. For one, it has been widely regarded as one of the most successful cases of Technology Parks in Brazil; in addition, it has experienced a singular trajectory in the oil & gas sector, through a fast boom of large and small companies interested on joining the park to explore the sector. It is safe to situate the PTEC-UFRJ among the most famous cases in the country.

3.3 Case study scope and design

According to Yin (2018), there are six common sources of data to be collected in case studies: documents, archival records, interviews, direct observation, participant-observation, and physical artefacts. This work will mostly take advantage of two of those: documents and interviews.

To perform the analysis under the chosen theoretical model, a historical perspective of both the organization and the environment was needed. To this end, longitudinal process data was gathered regarding the evolution of the case, the data was then organized chronologically in terms of what Langley (1999) calls a narrative

sensemaking strategy, preserving a high fidelity to the actual data and sequence of events.

Collecting data for building a historical perspective regarding the environment preceded the collection of data specific to the selected Technology Park. The basic challenge here was to select a specific frame to contextualize the environment, since in organizational analysis it is always possible to expand the scope of environmental analysis. Regarding Technology Parks, for instance, which are located at the intersection of universities, government and the productive sector, historical analysis of universities in general, or of specific universities, could be part of the scope of study, depending on the objectives of the work, theoretical lenses, etc.

This study represents the environment in terms of: (a) an overall outlook of Technology Parks in the country and the Rio de Janeiro region, (b) public policies and programs for Science, Technology & Innovation, and (c) one specific institution that played a major role in shifting PTEC-UFRJ's history. The reasoning for selecting this frame of analysis will be discussed in more detail at the introduction of the next section, dedicated to describing the environment.

The historical perspective over the environment also brings forth data that precedes the existence of the selected Technology Park. Given that Technology Parks can be said to bridge demand and offer for innovation (Radošević and Myrzakhmet, 2003), their pathways will at least partly depend upon the general state and size of the entire Innovation System (Freeman, 1987) of the country. To provide the eventual unacquainted reader with some degree of understanding the state of Science, Technology, and Innovation in Brazil, this study builds the historical perspective over a larger time frame.

The chronological order of events organized into a "thematic order". Historical descriptions were bracketed in terms of specific themes, the order of the subsections created for each theme followed a chronological order, as well as the order of events inside each subsection. This means that, eventually, the description of some subsections will end at a much more recent point in time than where the next subsection begins. The ordering of paragraphs followed a similar logic. For the sake of illustration, one paragraph may address events that started in 2015 and ended in 2018, while the next paragraph may go back to 2015 if needed.

3.1.1 Data collection

Data regarding the environment was collected through documents only, whereas data regarding the selected Technology Park utilized documents and interviews. Documental data for both the environment and PTEC-UFRJ were gathered through the following types of sources: Academic journal articles; Newspapers and magazines; Laws and other legal instruments; Institutional reports of the relevant organizations; Websites (provided they belonged to known news outlets, educational and governmental institutions, or entities directly associated to the parks);

These data were gathered from the period spanning February to October 2020. All of the sources have been collected and saved into digital storage to be kept should the verification of data here described be necessary in the future, following Yin's (2003) prescription that not only the narrative text present in the research report should be kept, but also a case study database containing all of the raw data. The web address for every online source of information was also linked in the references section of this work, with a timestamp of the last time it was accessed by the author. These addresses were also stored in digital spreadsheets to aid the construction of the narrative, in chronological order, with a summary of the contents, and organized by themes.

Whenever available, data regarding the same topic from different documental sources were checked against each other in order to identify discrepancies. Whenever these were found to be considerably different or contradicting, they were discarded or brought into question during the interviews.

This is in line with Yin's (2003) statement about case study research "[it] relies on multiple sources of evidence, with data needing to converge in a triangulation fashion." (Yin, 2003, p. 15).

Some degree of quantitative data is also present throughout the historical accounts of the case, these constitute a mere aid to facilitate the capture of temporal evolution in some relevant data, and do not contradict the nature of qualitative research:

"One rather obvious but salient characteristic of qualitative research that is distinctive is that it entails, primarily, the analysis of data that has not been quantified. This is not to say that qualitative researchers never provide numbers to support some aspect of their analysis; it is perfectly acceptable to include numbers in a supporting role" (Belk, Askegaard, and Scott, 2012, p. 3)

Illustrative examples include the number of companies over time associated to the park, financial data regarding R&D investments, etc.

Interviews took place between April and November of 2020. Interviewees included former and current management personnel of PTEC-UFRJ, as well as representatives of other entities internal to UFRJ which are directly linked to the university's innovation ecosystem (UFRJ's Innovation Agency, COPPE's Business Incubator, and COPPE's Embrapii unit). The interviews were conducted online as video or voice calls over multiple platforms (the ones utilized were Skype, Zoom, and Google Meet, whichever was preferred by the interviewee), totalling 18 hours and 31 minutes of recorded audio. At the end of this subsection, a list of PTEC-UFRJ participants is provided in table 2, and a list of participants from other entities is provided in table 3, disclosing their identities in terms of job position and timeframe during which they were working at the park, ordered from first to last interview to take place. All interviews were conducted online despite geographical proximity between the researcher and the park and interviewees, due to the pandemic and lockdown conditions occurred in 2020 during the entire course of development of this work.

The interviews followed a semi-structured format. Starting with a general question for the interviewee to provide a description of hers or his academic and professional background. Following on to descriptions of how they got to work at the park, their roles inside the park, and which activities they usually perform. Then, general questions regarding the history of the park were asked, these could include a variety of topics and events depending on the position occupied by the interviewee and the time period during which he or she was present at the park. This adaptation was made possible due to previous knowledge regarding the history of the park, achieved through documental data collection (and, after the first one, any previous interview). That is the reason why interviews were the second, not first, step in the process of data collection. In addition, a qualitative research design allows for following topics presented by interviewees, by "asking questions that could not have been anticipated prior to immersion" (Belk, Askegaard, and Scott, 2012, p. 4), as advanced by Rubin and Rubin (1995, apud Yin, 2003, p. 89), "your actual stream of questions in a case study interview is likely to be fluid rather than rigid". Finally, perceptions of interviewees regarding the challenges faced by the park in the past and the ones they might face in

the future were also discussed. All interviews were recorded and saved in digital storage - this was done with the previous consent of all interviewees.

Both former and current management personnel were interviewed, plus personnel from other related UFRJ entities, totalling 14 people. The interviews had an average duration of one hour and a half (ranging from forty minutes to one hour and forty-five minutes). Contact was established through e-mails and LinkedIn, and one important factor in finding the first participants for interviews lies in the connection between the park and the school where the author conducted this work (both being part of the same university, with links between ex-students and the park).

Yin (2003) notes that “the most desirable option is to disclose the identities of both the case and the individuals” (p. 157), if this is possible, the readers might be able to draw connections between what is being exposed in the narrative and other information they may have acquired about the case elsewhere, moreover “appropriate criticism can be raised about the published case” (p. 158). However, the author did highlight that there may be reasons to keep some level of anonymity within the case study, and one of the reasons is that “the purpose of the case study may be to portray an ‘ideal type’, and there may be no reason for disclosing true identities in such a case” (p. 158). As mentioned before, the selected Technology Parks was to be analysed in terms of the “archetypes of success and failure” (Fleck, 2009), therefore fitting into this situation. When this is true, some kind of compromise in terms of identity disclosure should still be sought, where one of Yin’s (2003) suggestions is “to name the individuals but to avoid attributing any particular point of view or comment to a single individual” (p. 158). Considering these matters, two decisions were made: (a) the identity information of participants are disclosed in tables 2 and 3, in terms of job position and time period worked within the park (or other entities previously mentioned); and (b) no comments or points of view will be directly attributed to a specific interviewee throughout the narrative and/or analysis, since this direct attribution would provide no additional benefits for the purposes of the research. Quotes from interviewees will be marked with a letter identification (e.g, “interviewee A”, “interviewee B”), which will be kept the same for each interviewee throughout the entire work for the sense of continuity and diversity, these letters have been randomly attributed and do not follow any order.

Following on in this line, Creswell (2013, n.p.) stressed that “researchers need to anticipate the ethical issues that may arise during their studies”, because qualitative research “involves collecting data from people, about people” (Punch, 2005, apud Creswell, 2013, n.p.). To address these issues, Creswell (2013) listed some suggestions, such as: disclose the purpose of the study, avoid collecting and/or disclosing harmful information, select a site without vested interests, respect the privacy of participants, use aliases or pseudonyms for individuals and places, among others. Some of the measures undertaken to abide by these guidelines were: all participants were aware of the nature of the interviews before accepting it (the subject of study); the goals of the study were explained at the beginning of each interview; all participants explicitly agreed to be recorded; all participants were informed that, should they wish any information to be deleted from recordings, not mentioned or not taken into consideration during the study, they were free to request removal at any time; should interviewees not wish to answer any given question, no pressure was made to force them into answering; potential participants were contacted only once regarding the request for an interview, non-answered requests were not reiterated as to avoid any possible discomfort or pressure; information identified as strategic to the organizations and/or people involved should not be disclosed, even if relevant for the analysis; the researcher did not have any kind of direct personal connections linked to the selected organizations prior to the study;

Finally, interviews were later fully transcribed for the purpose of data analysis, and stored in the digital case study database. In total, the 14 participants heard during 13 interviews (one interview had two participants, as shown in Table 3), yielded 213 pages (115,230 words) of transcribed text, word-by-word, which was entirely performed by the author alone, as to not expose the data to third parties. Data analysis will be described below over the next subsection.

Langley, 1999) calls accuracy “close data fitting”. Analysis under the archetypes of success and failure (Fleck, 2009) calls for a high degree of accuracy. The sensemaking strategy proposed by Langley (1999) to be most appropriate for high accuracy is the Narrative, which will therefore be applied in this work. Thus, section 4 (historical data), will provide the reader with the entire narrative regarding the environment (as previously defined), and section 5 will provide a historical perspective of the selected Technology Park for this case study, showcasing most of the raw data collected during the study after being organized into a narrative.

Langley (1999) noted that accuracy poses trade-offs in relation to simplicity and generality. Low simplicity and generality, however, limit the power for the process data analysis to construct theoretical propositions. This does not seem to represent a problem for the scope of this study, since the aim is to apply theoretical propositions previously developed elsewhere. According to Yin (2003), the “most preferred strategy is to follow the theoretical propositions that led to your case study” (p. 111), and “the proposition helps to focus attention on certain data and to ignore other data” (p. 112). As such, the narrative is not the final product of this study; it constitutes a step in-between to aid in the process of data analysis under a previously selected theoretical model. For this reason, the narrative will be presented on a section separate from the data analysis, but parts of it will be recalled during the analysis section

The data collected was analysed in order to identify chunks that fit into the specific categories of Fleck’s (2009) theoretical model. When possible, these were classified as evidence of either adequate or inadequate responses to the dimensions proposed by Fleck (2009). It is possible that, at times, for one or many of the dimensions in the model, there still exist data describing the challenges, as perceived by PTEC-UFRJ, but there may be a lack of information to classify its responses in terms the polar archetypes. In such cases, data was presented as descriptions of the specific challenge, considering that these could still provide valuable insight for the reader and reflections regarding the challenges which might also be faced by other Technology Parks in Brazil.

Finally, while the challenges of growth (Fleck, 2009) are defined in a general sense, that can be applied to multiple types of organizations, the application of this framework on each specific case leads the researcher to face instantiations of the general challenges. These instances carry specificity to either the organization alone,

the environment, and/or the type of organization being analysed. To fulfil the secondary objective of this study, the analysis of growth challenges faced by PTEC-UFRJ seeks to identify possible instances that can potentially be related to *Brazilian Technology Parks in public universities*, as opposed to *exclusive to PTEC-UFRJ*. Section seven ("Discussion") synthesises some of these far from exhaustive results, which conclude the secondary objective of this work.

4 Environment

This section will be structured as follows: 4.1 will provide further explanation regarding the selection of a specific frame of analysis for the environment. 4.2 will provide an overview of Technology Parks in Brazil and the Rio de Janeiro region. 4.3. will provide a historical account of public policies and programs towards Science, Technology & Innovation in the country, and section 4.4 will provide an account of Petrobras' R&D interactions with UFRJ and the discovery of the pre-salt oil reserves.

4.1 Framing the environment

The theoretical framework set forward by Fleck (2009) the analysis of longitudinal data regarding the environment surrounding the target organization. Organizations operating in the same environment can have different responses and outcomes under similar circumstances, due to their effectiveness among the different growth dimensions proposed in the framework. The environment can be subdivided into (a) natural environment, (b) institutional environment, and (c) competitive environment.

The natural environment has not raised much relevant information in terms of challenges or opportunities. Though themes of sustainability are relevant to the Technology Park, this is a general concern for all organizations, not specific to Technology Parks or to PTEC-UFRJ, and these lie more in the area of future risks and opportunities as opposed to past events for a historical perspective of PTEC-UFRJ and its environment. For these reasons, the environmental description will not delve into the natural dimension.

As for the institutional environment, three main areas of policies and regulations were first identified as most relevant to PTEC-UFRJ: (a) public policies for Science, Technology & Innovation, (b) public management regulations, and (c) UFRJ's internal policies and regulations. It was identified that UFRJ as of yet does not possess a consolidated framework of policies for innovation, there is a policy for Intellectual Property (IP) and licensing, but IP handling lies more in the attributions of other actors in the university and is not a direct concern of PTEC-UFRJ. As for public management regulations, these are relevant to the extent that many regulations may limit or slow down the functioning of PTEC-UFRJ (if compared to Technology Parks that might be managed under a private juridical form), some aspects of the analysis in terms of

Fleck's (2009) growth challenge (for instance, entrepreneurial versatility and fund-raising) may need to be adapted to take these limitations into account, but otherwise public management regulations are too broad in scope to be included in the analysis of a single instance of a single type of public organization inside a work that is not directed towards the public management literature.

Science, Technology & innovation policies, and regulations were deemed to be the most relevant perspective for PTEC-UFRJ out of the three identified. As observed by Radošević and Myrzakhmet (2003), Technology Parks cannot thrive in an environment where, either or both, (a) the private sector is generally disengaged from R&D&I activities, and (b) scientific inquiry in research institutions (universities here included) are not sufficiently developed. According to these authors, "innovation policy addresses three dimensions: supply of innovation; demand for innovation; and bridging between them" (p. 12). While Technology Parks lie on the third dimension, all three of them are relevant to analyse the environment a park is inserted into, for the reason mentioned before (considering public policies and government programs are commonly deemed essential to develop both R&D&I in the private sector and academic capabilities). One section of environmental description will be dedicated to a historical perspective of public policies and programs for all three sides (academic research, private R&D, and bridging). Not only is a historical description of public policies and programs necessary, but also a description of their impacts, therefore the section dedicated to public policies and programs will contain one subsection with a brief description of the results by providing some publicly-available quantitative data.

The last environmental dimension is the competitive environment. In the case of PTEC-UFRJ, three main categories of potential competitors were first identified: (a) other Technology Parks, (b) other internal actors of UFRJ's innovation ecosystem, and (c) other types of organizations that articulate the private sector and universities.

Besides Technology Parks, external organizations that could potentially compete with PTEC-UFRJ are manifold, ranging from venture capital and venture builders, to online platforms that congregate entrepreneurs and researchers, to other research institutions in the region, and much more. However, on a historical perspective, none of these were indicated by our data to have played any major role in the history of PTEC-UFRJ. This Technology Park has its identity anchored to interactions with UFRJ, not to universities or research institutes in general, the fact that

no other external organization has this characteristic may be the reason this type of external competition has not been significant. Although these could be relevant in the future, for a historical perspective of PTEC-UFRJ, a description of these was deemed not fundamental.

As for other Technology Parks, our data indicated that the relationship between PTEC-UFRJ and other Technology Parks has strongly tended towards cooperation instead of competition. This may be simply the natural steps of early-stage sector formation, where competition will arise in the future, or it may be that the relationship intra-Technology Parks is better understood as cooperative on a network level instead of competition (Phan, Siegel, and Wright, 2005). Regardless, the competitive environment for PTEC-UFRJ with other Technology Parks has not been too relevant on a historical perspective. The description of the environment will however provide an account of the overall scenario of Technology Parks in the country and the Rio de Janeiro region (where PTEC-UFRJ is located), for the unacquainted reader to better understand the overall context PTEC-UFRJ is situated in.

PTEC-UFRJ has one particular characteristic in that its trajectory was heavily impacted by the discovery of oil reserves (pre-salt) made by Petrobras in the late 2000s, and the extensive history of interactions between this company and UFRJ for R&D&I purposes over the years (pre-dating the aforementioned discovery). One additional section of environmental description will be presented with information regarding the event of the pre-salt discovery and this relationship. This is not fitted into one of the three environmental dimensions mentioned before because, in reality, this information could be delivered as parts of PTEC-UFRJ's history in itself, first as precedents for its creation (imprinting a culture of university-industry interactions at COPPE) and later as justification for the arrival of companies at the park. However, a separated section was chosen as appropriate to allow a higher level of detail.

The scope of environmental description chosen for this work is summarized in the figure below, these will be presented in individual sections in the order listed here. The history of PTEC-UFRJ will follow immediately after the sections dedicated to environmental descriptions.

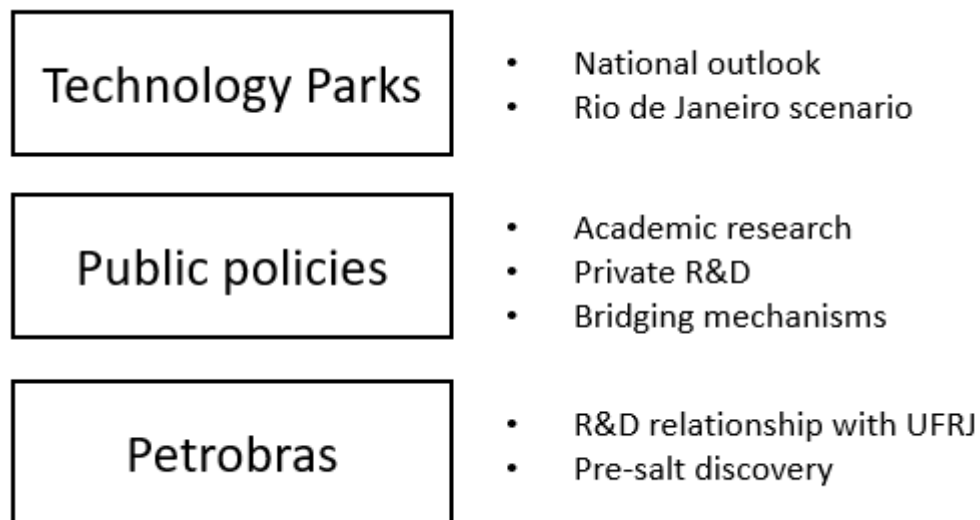


Figure 4 – Scope of Environmental Data
Source: created by the author

4.2 Technology Parks in Brazil

According to Anprotec (2008), Technology Parks in Brazil mostly lie within the “third generation” of parks, meaning deliberately introduced in the realm of national or regional public policies as tools for economic development: “in general, the [Brazilian] parks are related to a formal program of regional planning, making up one important piece of the strategy for economic and technological development” (p. 7).

Currently, the legal definition of Technology Parks in Brazil is described in the 2016 Innovation Law as the following:

“A planned complex for the development of businesses and technology, which promotes a culture of innovation, industrial competitiveness, business training, and synergies between the activities of scientific research, technological development, and innovation, among enterprises and one or more Science and Technology Institutions (STIs), which can be interrelated or not.” (Brazil, 2016a)

According to a 2019 study undertaken by the Support Center for Technological Development of the University of Brasilia (CDT/UNB), the first Technology Park in Brazil dates back to the 1980s, but the movement only picked-up speed in the past two decades. The number of TPs in the entire country went from 10 in the year 2000, to 103 at the end of 2017. These numbers account for TPs both already operating and in planning or implementation phases, as distributed in the figure below:

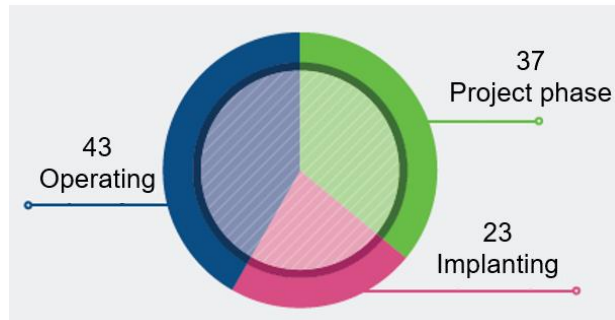


Figure 5 – Number of TPs in Brazil at the end of 2017

Source: Translated from Indicadores de Parques Tecnológicos - Fase 2 (CDT/UNB, 2019)

According to the study, TPs (in all phases) are present in every region of the country: 6 in the North region, 9 in the Northeast region, 10 in the Midwest region, 37 in the South region, and 41 in the Southeast region. The evolution in number of TPs in the entire country from 2000 to 2017 can be seen in the figure below (accounting for TPs operating and TPs in planning or implementation stages):

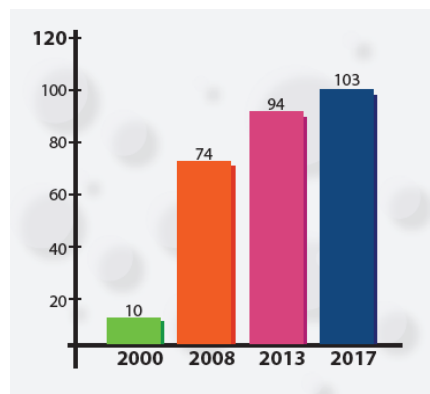


Figure 6 – No. of Technology Parks in all stages of development

Source: Indicadores de Parques Tecnológicos - Fase 2 (CDT/UNB, 2019)

From 2000 to 2008, sixty-four new initiatives had been reported, it was during this period that the Technology Park of the Federal University of Rio de Janeiro (PTEC-UFRJ) entered operational stage. From 2008 to 2013, twenty new TP initiatives had been recorded, while only nine new initiatives were recorded from 2013 to 2017. This shows a slowing-down in the rate of new TP initiatives, which could represent the nearing of a saturation point or simply a reflex of economic and political instabilities in the country (CDT/UNB, 2019, p. 38).

Naturally, not all TPs which enter formal planning or implementation stages make it to actually being operational, some even might go backwards to a lower stage (CDT/UNB, 2019, p. 41), and some go through all stages much faster than others. In

fact, not a single TP went from the planning stage to being operational during the four year period from 2013 to 2017, and 79.8% of TPs which were in the planning or implementation stage prior to 2013 didn't follow through to the next stage.

It was estimated that 1,337 companies were actively operating inside Technology Parks across the country at the end of 2017, employing 38,365 people. While the TPs' themselves employed 685 people for their direct management and operations.

CDT/UNB's study inquired TP managers regarding the challenges they perceive for the further development of TPs, to which the most common answers were: "obtaining financial resources, a lack of professionals experienced in managing innovation environments, the need to create an innovation-driven culture, and a better connection between science and the market".

Regarding sources of funding, as shown in the figure below, in 2017, Brazilian Technology Parks had, in aggregate, reported a higher participation of state and municipal financial investments than investments from the federal government and private investments (at the end of 2016):

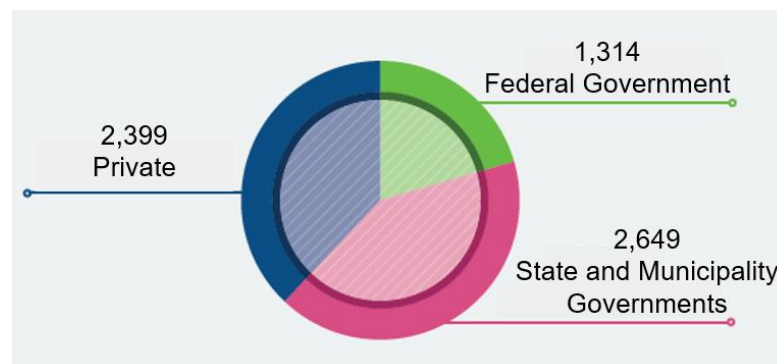


Figure 7 – Sources of financing for Brazilian Technology Parks (in millions of BRL)
Source: Translated from Indicadores de Parques Tecnológicos - Fase 2 (CDT/UNB, 2019)

There is a reasonable participation of the private sector, at 37.71% of total investments, nevertheless, Brazilian Technology Parks, in the aggregate level, seem to be mostly still in the government-led growth mechanism (Koh, Koh, and Tschang, 2005), which would be expected given that the majority of TPs in Brazil (as of 2017, when the survey was conducted) are indeed in their early stages, most being at planning or implementation phases.

When considering only Technology Parks already in the operational stage, the private sector represents 47.3% of financing, but there are notorious examples of Technology Parks in Brazil that operate with a heavy majority of private funds, such as the São José dos Campos Technology Park. While TPs in the planning stage report 0% private sector investment, and TPs in implementation stage report 5.3% of private investment. This fits well within the literature (e.g., Koh Koh, and Tschang, 2005; Radošević and Myrzakhmet, 2009) that regard government investing as critical during the early stages of Technology Parks.

“The results reiterate the relevance for the federal government to reduce risks for enterprises and entrepreneurs until a park effectively starts its operations. Political and economic uncertainties can exacerbate private investors’ risk aversion, thus, the government’s role is essential so that initiatives in planning and implementation stages, which hold potential and good business plans, become viable” (CDT/UNB, 2019, p. 61)

In general, operational Technology Parks in Brazil have struggled to reach breakeven in order to continue operations without government support. PTEC-UFRJ was reportedly among the first Technology Parks in the entire country to reach breakeven on operational costs, doing so in the year of 2015.

Technology Parks in the country have for the most part remained territorially distant from one another (one notorious exception is the city of Campinas, São Paulo, that counts with five operational Technology Parks as of 2020), this is even apparent in a somewhat common practice of naming Technology Parks after the city they are located in. Data collected through our interviews suggested some kind of “territorial respect” that may exist. As a result, the relationship between Technology Parks in the country has tended, in general, much more towards cooperation than that of competition. Technology Parks are networked through many associations, on the national level there is Anprotec, an association of innovation environments (e.g., incubators, technology parks) created in 1987, and ANPEI, a national association of companies that engage in R&D&I (articulation with universities and research institutions is part of ANPEI’s objectives), created in 1984. In addition to the national associations, regions that hold a significant number of innovation environments commonly have their own local associations. Finally, a number of Brazilian Technology Parks are also members of the International Association of Science Parks (IASP). These associations routinely hold events that bring managers and employees of Technology Parks together and spark cooperation. Cooperation is achieved through

multiple channels, such as direct articulations, visits, personal contact, events and general sharing of information and discussion of best practices. At least in the case of PTEC-UFRJ, we have found that informal relationships between personnel from different Technology Parks are important channels for mutual learning, and these associations have been relevant channels to create social connections between these people.

Some of the most well-known Technology Parks in the country, in no particular order, are: The São José dos Campos Technology Park, established in 2006 in the state of São Paulo, with a heavy presence of the Aerospace, Defence and ICT sectors; Porto Digital, established in 2000 in the state of Pernambuco, with a heavy presence of the ICT and Creative Economy sectors; Tecnopuc, established in 2001 in the state of Rio Grande do Sul, with an emphasis on ICT, Creative Economy, Energy, and Health sectors; Tecnosinos, established in 1999 in the state of Rio Grande do Sul, multi-sectorial; BH-TEC, established in 2012 in the state of Minas Gerais, multi-sectorial; And PTEC-UFRJ, established in 2003 in the state of Rio de Janeiro, multi-sectorial with a heavy presence of the oil & gas sector.

4.2.1 Technology Parks in the state of Rio de Janeiro

In the state of Rio de Janeiro, as of 2020, there are only two Technology Parks in full operation, UFRJ's Technology Park (PTEC-UFRJ), and Serratec. PTEC-UFRJ was originally named "Rio's Technology Park", but the name was changed in 2014, taking into consideration that other parks could emerge in area, the identity of the park was anchored to the university, as opposed to the city or state. The second park, Serratec, is located at the cities of Petropolis, Teresópolis, and Nova Friburgo, it is not linked to just one single university or research institute (it has links, for instance, to the Catholic University of Petropolis, Fiocruz, CEFET-RJ, and UFF, among others), and is focused on the sector of Information and Communications Technology (ICT), having 25 member companies as of June 2020. Serratec's model is a joint effort composed of multiple programs and support structures, developed by the municipal governments of the three cities involved, in order to attract companies to anywhere within all three cities (as opposed to a specific land area). But there are physical facilities, such as co-working spaces, and active articulation between companies and universities or

research institutions. According to Serratec's website, it is "the only technology park in Brazil to not be confined in a demarked area, having [instead] a regional scope". Serratec as a formal institution was consolidated in 2019, however the Technology Park per-se traces back to programs developed between the municipal governments of Petropolis and Teresópolis (and Nova Friburgo later on) that have began at least two decades ago.

In addition to PTEC-UFRJ and Serratec, perhaps the only other organization that could be considered a Technology Park in Rio de Janeiro was the BioRio Pole. BioRio was another Technology Park linked to UFRJ (located inside campus and oriented towards interactions between resident companies and the university), although not owned or managed by UFRJ. Created in 1988, BioRio was the first Technology Park for Biotechnology in Latin America. A non-profit organization, named Bio-Rio foundation, was responsible for managing all of the park's infrastructure and services. It offered physical facilities to house SMEs engaged in R&D activities, had its own incubator, shared laboratories, and provided operational services as well as business planning, mentoring, and assessment services. In 2018, UFRJ's concession to the BioRio Foundation expired and was not renewed, at this time, UFRJ deliberated that the BioRio Pole would be transferred over to be managed under PTEC-UFRJ, i.e., what were two distinct Technology Parks would become one. Problems related to legal uncertainty, with conflicting interpretations of the Innovation Law (specially related to the "equality of opportunity" for companies that is mentioned on it), resulted in UFRJ's representatives of the Federal General Attorney's Office deliberating that all companies which were already operating inside BioRio would first have to completely leave the park before being able to participate in public offerings to re-join under PTEC-UFRJ. This situation was still unresolved as of 2020 and the future of BioRio is therefore uncertain.

Although not many Technology Parks have entered operations (and effectively received companies) in the state of Rio de Janeiro, a number of Technology Parks in the region are either under the stage of planning or implementation as of 2020. At least seven projects have been identified and are listed below:

Currently, there are efforts being taken for the creation of a new Technology Park in the city of Maricá. The park is supposed to integrate all of the basic components of a fully-fledged park: resident companies, partnerships with research institutions, a

business incubator, and laboratories. Interestingly, the Technology Park of São José dos Campos was selected by the municipal government of Maricá to be responsible for structuring and implementing the new Technology Park (the contract was signed on the 4th of July, 2019). The park is supposed to work under a partnership with the National Technology Institute (INT), with a strong emphasis on technologies pertaining to the oil & gas industry, but also on health sciences, environmental engineering, 4.0 Industry, and ICT. A partnership with the Federal Fluminense University (UFF) was also announced to bring a pre-incubation, or acceleration, program to the park, named “Startup School”.

In the Federal Rural University of Rio de Janeiro (UFRRJ), the construction of a Technology Park has been proposed to be housed in its Seropédica campus, with an emphasis on technologies for the agriculture and livestock sectors. The proposal for its governance model strikes remarkably similar features to that of PTEC-UFRJ.

The Federal Fluminense University (UFF), through its NIT (AGIR), in conjunction with the municipal government of Niterói, are implementing a new Technology Park named “Innovation Peninsula”. Announced at the end of 2016, the model is not based on a single physical infrastructure or confined space, instead, the municipal government has identified old buildings, across multiple and adjacent neighbourhoods in the city, which are to be renewed in order to house companies. The planning is for the Innovation Peninsula to have an emphasis on the industry of video games development, with SMEs that wish to acquire scientific knowledge as a target group. UFF would be responsible for providing matchmaking services, to articulate demands from companies with researchers that could provide the required expertise inside the university.

The National institute of Metrology Standardization and Industrial Quality (Inmetro) is currently implementing its new Technology Park in the city of Duque de Caxias. The park is planned to offer all basic features of a full-fledged park: a physical infrastructure with terrains and buildings for housing companies, support services for associated companies, a co-working space, infrastructure for hosting events, and more. Inmetro also offers an incubation program in the same location since 2002. As of 2020, there are four types of incubation performed by Inmetro: (a) Research and technological development for projects presented by companies of all sizes, which may want to take advantage of support provided by Inmetro researchers and/or its research

infrastructure, (b) business projects for entering the new Technology Park, where the company needs both scientific and business/management support from Inmetro, with the aim to, in the future, establish research centres or production units inside Inmetro's park, (c) Application and exploration of Inmetro-created technologies, and (d) support for independent inventors who seek future industrialization of their inventions. The new Technology Park is to be focused on Inmetro's technological and scientific expertise areas, such alternative energy, green chemistry, and health.

The municipal government of Angra dos Reis has announced, in mid-2019, the creation of a new Technology Park in that city, named "Angra Tech City". The park is planned to focus on technology-based businesses and projects in the areas of oil & gas, nautical and naval, energy, and sustainability. CEFET-RJ was invited to fill the academic leg of this undertaking.

The Carioca Factory of Catalysts (FCCSA - a private company), has announced plans to establish a Technology Park inside its physical facilities, the park was named Santa Cruz Science Park (referring to the neighbourhood in Rio de Janeiro where FCCSA is located). The park was planned to be financed by the company along with FINEP resources. Offering physical facilities for housing "partner companies", a technology-based business incubator, a social incubator, and a flexible plant for research and production of adsorbents, catalysts, and intermediate products for the chemistry industry (focused on oil & gas, and petro chemistry). According to the company's website, Petrobras and UFRJ are partners for providing "technological expertise".

In 2016, the Rio de Janeiro State University (UERJ) and the prefecture of Resende announced plans to create a Technology Park on a 100 thousand square meters area in the city, which belongs to UERJ, to be initially financed by Rio de Janeiro's public foundation for supporting research (FAPERJ). Since 2007, UERJ has a campus in that city, which houses a unit of its Technology School, and also a business incubator. The new Technology Park was planned to include shared laboratories and physical space for allocating companies.

4.2.2 Policies for innovation and R&D incentives

Authors such as Radosevic and Myrzakhmet (2009) observed that while developing countries have been using Technology Parks as tools of public policy to support economic growth and technological innovation, Technology Parks themselves cannot make up for low levels of R&D&I engagement from the part of the private sector, which can be a common characteristic of developing nations. In other words, Technology Parks need thriving demand from the private sector, in addition to universities and research institutions with the capability to offer scientific expertise. The literature on innovation has vastly confirmed that governments need be actively participating in the development of Science, Technology, and Innovation capabilities in a country. This section will explore instruments applied by the Brazilian government in the three dimensions of innovation policy: “supply of innovation; demand for innovation; and bridging between them” (Radosevic and Myrzakhmet, 2003, p. 12), with a chronological perspective.

4.2.2.1 Public support for research in Brazilian universities

Perhaps the roots of the movement to consolidate modern scientific research in Brazil, in organized form and with continuous institutional support from the government, can be symbolized with the establishment of both CNPq (National Council for Scientific and Technological Development) and CAPES (Coordination for Development of Higher Education Personnel) in the year of 1951, two entities that continue to be central actors in the Brazilian scientific and educational systems to this day (it is said “symbolized” here because the history of both institutions trace back to years prior to their formal establishment in 1951). The objectives of CNPq upon its creation have been summarized by the entity as the following:

“The law which created the Council established its objectives as promoting and stimulating the development of scientific and technological inquiries, through the provision of resources for research, training researchers and technicians, cooperating with Brazilian universities, and exchanging with international institutions. CNPq’s mission was broad, some kind of a ‘bigger-state for science, technical affairs, and industry, capable of tracing safe paths for works of science and technology in the country, systematically developing and coordinating them.” (CNPq; Brazil, 1951)

While CNPq was created with a role in supporting research through providing resources, training, networking and coordination, CAPES was conceived with the objective to combine different efforts needed to secure the availability of qualified human resources necessary to sustain the growing industrialization happening in Brazil at the time (Gouvêa, 2010). Eventually, the role of the two institutions became even more synergetic and complementary with the consolidation of scientific research in public educational institutions of the country.

CNPq “was established in 1951 due to the efforts of admiral Álvaro Alberto in consolidating governmental control over nuclear activities” (Ladeira Jr, 2013, p. 86). Admiral Álvaro Alberto da Motta e Silva was a Brazilian representative in the United Nations’ (UN) Atomic Energy Commission and the Security Council. According to CNPq’s institutional website, the creation of a governmental entity strictly specialized in fomenting scientific development had been in the talks for a long time before the actual creation of CNPq (at least since the 1920s). The observed scientific developments and impacts during the second world war, “mainly nuclear energy” (CNPq), set in motion a wave of scientific articulation in many countries in order to speed-up efforts in this area. Admiral Álvaro Alberto officially proposed the creation of a “society for scientific progress” to the Brazilian government in 1948, from these efforts, CNPq was finally established through the Brazilian Federal Law No. 1310 of 1951 (CNPq; Brazil, 1951). Still according to CNPq’s institutional website, the Council was from its inception conceived to promote scientific inquiries in any knowledge area, but during its first years (1951-1954), while Admiral Álvaro Alberto was the head of the Council, it had a higher emphasis on nuclear energy, which had become strategic among governments due to the Second World War. In 1956 the Brazilian National Council for Nuclear Energy (CNEN) was established as a separate entity, which took responsibility for nuclear activities out of CNPq’s hands. In the same year, CNPq became responsible for formulating the national Science and Technology (C&T) policies (Dudziak, 2007, p. 178), remaining the central actor in the planning, coordination, and development of Brazilian scientific strategies until the Ministry of Science and Technology was created in 1985.

While nuclear technology was a driving concern behind the creation of CNPq, the fast industrialization of the country happening during that time drove the creation of CAPES. The socioeconomic backdrop of that era raised concerns surrounding the

availability of qualified human resources to sustain further growth: the 1950s constituted part of a “long process which characterized the development of industrial capitalism in the Country. During those years, development models for the country were consolidated based on accelerated industrialization” (Gouvêa, 2010, p. 532). It was in this context that CAPES was conceived, to ensure the availability of qualified human resources necessary to sustain the growing industrialization of that time (Gouvêa, 2010). CAPES resulted from the efforts of multiple actors, but Anísio Teixeira, at the time holding office as the Secretary of Health and Education for the State of Bahia, is usually credited as playing a central role in idealizing the entity (Gouvêa, 2010, p. 531). In 1950, Teixeira sent a letter to the then Brazilian Minister of Education, Clemente Mariani, in which he proposed actions to be taken regarding the system of higher education institutions. Teixeira suggested, among other things, that selection criteria for students should be elevated, that raising the quality of professors was critical, and that the country needed to analyse the levels of real demands for professionals, to better address the gaps. Teixeira noted that an initial offering of qualified professors would not be feasible solely with resources available in the country, so international programs were suggested: bringing professors from abroad, and granting scholarships for Brazilians to study at international institutions (Gouvêa, 2010, p. 530). These objectives constituted “the pillars of CAPES’ process of formation and implementation” (p. 530), from where the entity further incremented its roles throughout the years (p. 536). In a nutshell, CAPES “bet on perfecting higher education personnel in the country and on the consolidation and institutionalization of post-graduate education”.

Both CNPq and CAPES were essential to consolidate scientific research in Brazil. CAPES was critical in defining, organizing, spreading, and evaluating graduate programs in Brazilian universities. While CNPq gradually had some of its attributions diluted (specially in terms of strategic planning and policy making) to the Ministry of Science and Technology and other government entities born later on, it remained a central actor in funding, coordinating, and networking activities related to research, which developed stronger in public universities much due to the consolidation of graduate programs directed towards research.

During its first years, CAPES oversaw the development of basic grounds for consolidating graduate level programs in the country. As a result of efforts grouped into

a program named “Programa Universitário”, started in 1953, CAPES brought foreign professors, established exchange programs, and granted scholarships to train professors for higher education, both in the country and abroad. 155 scholarships were granted in 1954, growing from 79 the year before (CAPES, 2012 apud Patrus, Shigaki, and Dantas, 2018, p. 644).

According to Sucupira (1980), graduate level programs in Brazil were effectively consolidated during the 1960s. Though Doctoral degrees were obtainable in Brazilian universities since their inception, these did not result from graduate programs: the title of Doctor would be granted upon presenting a thesis, not being attached to following specific educational programs inside an educational institution (p.3). In 1931, the figure of a doctorate degree resembling what is now adopted in the country was established through the Federal Decrees No. 19851 and 19852, which regulated that universities could grant doctorate titles through the presentation of a thesis and the completion of other requirements dictated by the educational institutes themselves.

Throughout the 1930s and 1940s, the concept of graduate programs slowly developed through somewhat isolated efforts. The most prominent law schools in the country adopted doctorate programs with the aim to qualify students to be professors, by including a level of education deemed not fundamental for those who would follow on as practitioners. This was not very impactful given that the degree, at the time, did not confer many advantages regarding the path for becoming a professor in the country. The most notorious example would be the Francisco Campos Philosophy, Science, and Languages School (FFCL) - created in 1934, giving birth to the University of São Paulo (USP) -, which brought European professors having doctorate degrees, and since its inception had made it mandatory that all professors should possess the title of Doctor (being the first in the country to do so). FFCL structured its doctorate programs to include a thesis presentation after the completion of other mandatory activities (Sucupira, 1980).

During the period from the 1930s to the early 1960s, the concept of graduate programs and post-bachelors specializations gradually developed in the country, as exemplified by the evolution in the discussion and changes surrounding a project to establish a policy to restructure Brazil’s educational system, known as the first Directives and Basis for Education (LDB), which finally condensed in the form of the Federal Law No. 4024 in December 1961. According to Sucupira (1980), LDB’s project

started as early as 1948 (p.11), and its development exposes major discussions surrounding the very concept of graduate programs and professional specializations, gradually evolving into its final form at the end of the 1950s, because with the “intensification of the process of [the country’s] development, turning universities into institutions for both education and research, simultaneously, was finally taken into serious consideration” (p. 11).

In 1965, the Federal Education council issued the Report No. 977, “inspired by the American university structural model [...], [which] regulated [graduate programs] in Brazil considering its definition, objectives, and [defining] the levels of Master and Doctor” (Dantas, 2012 apud Patrus, Shigaki, and Dantas, 2018, p. 644), validating a model which was not “entirely alien to Brazilian Higher Education” (Sucupira, 1980, pp. 16-17). This model was, for instance, as highlighted by the author, similar to what had been established for the newly created University of Brasília (UNB), upon its establishment in 1962 (p. 10). With the new legal framework in place, CAPES classified the already existing Post-Graduation programs and counted 27 Masters and 11 Doctoral programs in the country (CAPES, 2012, apud Patrus, Shigaki, and Dantas, 2018, p. 644).

Notwithstanding the pointed-out efforts previous to the consolidation and legal structuring of graduate programs in Brazil - occurred in the 1960s - Sucupira (1980) asserts that the first de-facto Master and Doctorate programs in Brazil date to the early years of the 1960s (p. 14), marking the consolidation of characteristics which are to this day held as defining traits of graduate programs in Brazil. As an example early programs of that decade, the establishment of the Chemistry Institute in the Federal University of Rio de Janeiro (UFRJ), approved in 1959, accounted for the first Master and Doctorate programs in the field of Chemical Engineering in the country, inaugurated in 1963 (p. 13). This was the embryo for the development of UFRJ’s graduate school of engineering (COPPE). Other early efforts were seen, for instance, in the Aeronautics Technology Institute (ITA) (p. 14).

Expansion of graduate level programs was swift during the following years. In 1977 there were 609 Master programs and 213 Doctorate programs (Sucupira, 1980, p. 17). The author noted that such “truly explosive growth” (p. 15) would naturally pose questions regarding the quality of these programs, for which he supported a “rigorous and wide” (p. 17) evaluation process.

To this end, CAPES had incorporated the role of evaluating the quality of graduate programs in 1976. Initially, the program was focused on “establishing the quality standards expected from Master’s and Doctoral courses in Brazil” (Patrus, Shigaki, and Dantas, 2018, p. 643). Initially, the focus was on visiting the facilities where programs took place to “assess their workings and offer assistance in perfecting them” (p. 647). In 1982, CAPES became responsible for elaborating the National Post-Graduation Plan (PNPG), for its second iteration (p. 646), through which the evaluation of programs was considered paramount to the strengthening of the system (Kuenzer and Moraes, 2005 apud Patrus, Shigaki, and Dantas, 2018, p. 646). In the 1980s, CAPES performed the visits through specialists in each area of knowledge, and added continuous collection of data through the introduction of forms (p. 646). The subsequent third version of PNPG (1986-189)

“...had as its guideline the institutionalization of scientific research at universities (CAPES, 2004) as well as the consolidation and improvement of the [graduate] programs’ performance and their integration to the system of science and technology, including the productive sector (PNPG, 1985). Aiming to fulfil this ambition, the III PNPG prioritized research at the universities, emphasizing their role in national development and the integration of [graduate programs] to the system of science and technology (PNPG, 1985). This was not enough, however, to overcome the tradition of Post-Graduation being intensively centered on teaching.” (p. 646)

According to the authors, CAPES, along with other entities such as CNPq and FINEP, worked until the 1990s on consolidating the focus of Brazilian graduate programs into research (p. 646).

All the while, CNPq was maintaining its role as promoters of science in the country, which naturally included support for research performed in graduate schools. Among some of CNPq’s activities, which they carry to this day, are the responsibilities for financially supporting the development of human resources (for instance, through scholarships to graduate students), funding selected research projects (which can be granted on demand from researchers, or through pushing bids for specific research topics), financially supporting and organizing national and international scientific meetings, and supporting scientific exchanges inside the country and abroad. All of these are naturally demanded by graduate schools.

CAPES and CNPq’s efforts on the federal level have been gradually complemented by the creation of state-level entities with similar objectives. With the São Paulo Foundation for Research Support (FAPESP) formally created in 1962, the

Carlos Chagas Foundation for Research Support of the State of Rio de Janeiro (FAPERJ) in 1980, and other similar entities that apply state resources into funding research projects, forming human resources, networking, and funding infrastructure for research and higher education institutions, similarly to much of what CAPES and CNPq performed on the federal level. At the federal level, other government efforts that extended beyond CNPq and CAPES have also been fundamental to consolidate graduate schools and academic research in the country. Of special relevance was the creation of the National Fund for Scientific and Technological Development (FNDCT) in 1969, to invest into infrastructure, resources, and projects necessary for the consolidation of science and technology in the country, managed by the Financer of Studies and Projects (FINEP) from 1971 onwards (and CNPq later on). The national Basic Plan for Scientific and Technological Development (PBDCT), on its first and second iterations (for the period of 1972-1980), among other things, set the development of technology and research infrastructure “especially in governmental areas” as priorities (Lemos and Cário, 2013, pp. 5-6). Through the application of FNDCT resources, FINEP played a major role in expanding academic infrastructure and graduate programs in the country, as part of the execution of the first and second PBDCTs. In 1994 a Federal Law consolidated the figure of Support Foundations for Higher Education and Research Institutes, which provided some celerity in project management for research and technology development in public universities and later on, with the introduction of innovation policies, were used as mechanisms to enable faster university-industry interactions. All the while CNPq and CAPES kept working on strengthening graduate programs and research with a varied set of efforts besides funding and coordinating, such as providing online access to vast literature (Portal CAPES), facilitated import of research equipment (CNPq Express), a database of researchers and research groups (Lattes), and more.

Government efforts to promote research and consolidate graduate programs in the country produced positive results, however, Brazil, to this day, still lags behind the more scientifically and technologically advanced countries in the world in a number of key indicators. For instance, figure 8 below shows a comparison of the proportion of PhDs per a hundred thousand inhabitants across 28 countries, including Brazil, as of 2013:

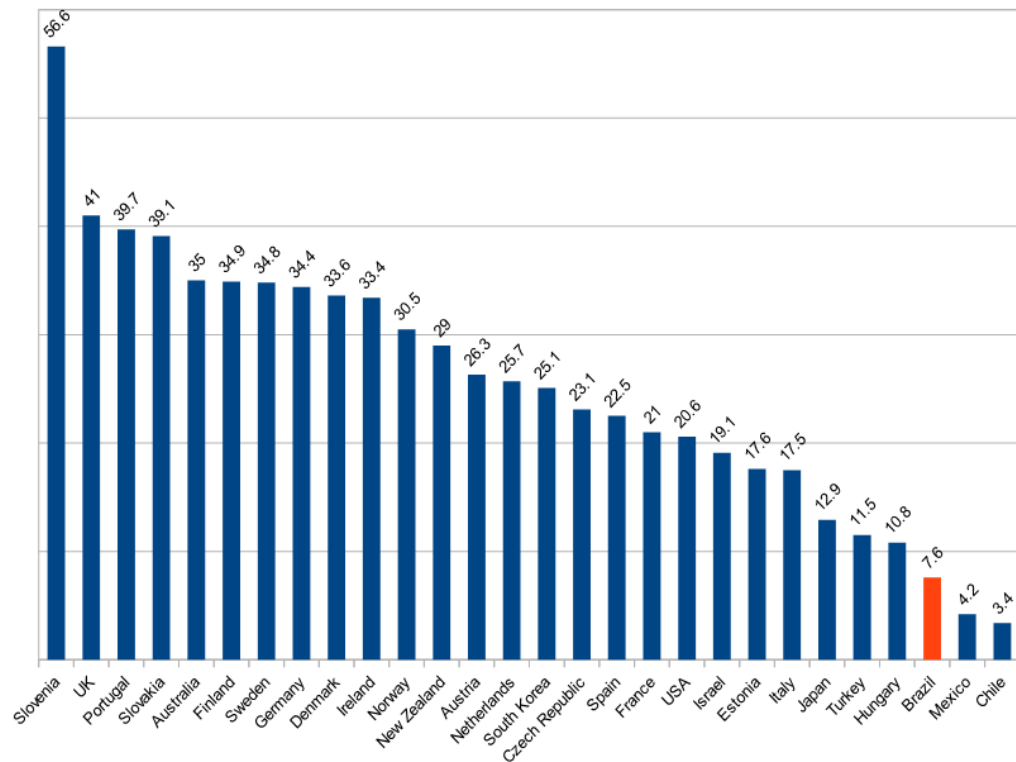


Figure 8 – Number of PhDs by 100 thousand inhabitants (as of 2013)
Source: OECD

However, even as Brazil still lags behind developed nations, a positive trend has been consistently observed over the years. This is clear in the figure below, which shows the number of PhD and master's degrees granted in the country every year:

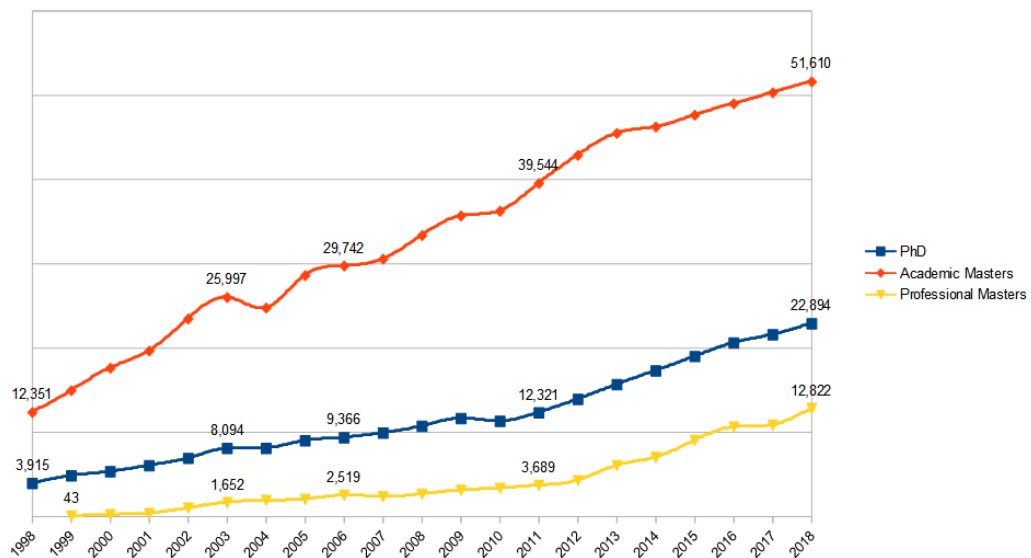


Figure 9 – Number of Master and PhD degrees granted in Brazil, by year.
Source: CAPES, MCTIC

The number of new PhD graduates per year and new academic MSc graduates per year grew 484.78% and 317.86%, respectively, when comparing the year 1998 to 2018. According to a study published in 2016 by the Center for Management and Strategic Studies (CGEE) - a Social Organization linked to MCTIC -, from 1996 to 2014, the state of São Paulo accounted for most of these degrees, with 36.6% of new PhDs and 24.7% of new masters, followed by Rio de Janeiro, with 12.9% of new PhDs and 11.9% of new master graduates within that time window. The majority of advanced degrees are granted by public institutions, which traditionally in Brazil have been responsible for most of the country's research output. In terms of research output, the increase in PhD and master's degrees has indeed been reflected in research output levels: In 2000, Brazil accounted for 1.14% of the world's scientific publications, and 44.15% of Latin America's. In 2017, those numbers jumped to 2.63% and 52.47%, respectively (SCImago Journal & Country Rank, accounting for journals indexed by Scopus).

4.2.2.2 Public support for research in the private sector

Unlike the scenario of government incentives for research enjoyed by public universities, through entities such as CNPq, CAPES, FINEP, FAPERJ, and more, over the second half of the 20th century, the private sector in Brazil . Even further, protectionist industrial policies in the country, common up to around the early- to mid-1990s, may have put Brazilian companies in a position where pursuing R&D&I was simply not too desired or needed. A well-known example of such protectionist policies, that could have impacted the interest of Brazilian companies for R&D&I, is the first version of the "Informatics Law" (IL).

According to Garcia and Roselino (2004), the first IL was based on a protectionist economic strategy, granting 'market reserves' to the Brazilian informatics industry - which means that restrictions were made to importing goods (software included) -, so that Brazilian products would dominate the internal market. In a nutshell, the first IL was based on the principle of a '*national similar*', which meant that whenever a Brazilian informatics product was available and deemed equivalent in functionalities to international products, importing was not allowed. The first IL, along with other protectionist policies applied in the country, resulted in a number of conflicts, as

exemplified in a 1987 The New York Times article reporting a case where six Brazilian hardware companies had required permission to license Microsoft's MS-DOS operating system to be used in their computers, which was denied by the Brazilian government. The then president of the USA in 1987, Ronald Reagan, released an official "Statement on Trade Sanctions Against Brazil" related to the first IL:

"I am today announcing my intention to raise tariffs on Brazilian exports to the United States and to prohibit imports from Brazil of certain computer products in response to the maintenance by Brazil of unfair trade practices in the area of computer products. [...] In response to these developments, I intend to raise tariffs to offset the lost sales opportunities for U.S. companies, estimated at \$105 million, and to prohibit imports of Brazilian informatics products covered under Brazil's market reserve policy. Should Brazil reverse its action [...] I will be prepared to lift these sanctions." (U.S. Department of State, 1988, p. 821)

At the time, the then Brazilian Minister of Finance, Luis Carlos Bresser Pereira, reacted by stating that the Brazilian policy was not going to be changed and suggested that the first IL was in the best interest of the country (Farnsworth, 1987). As is clear, informatics companies not only did not have incentives to innovate in order to compete with global players, but they also had an incentive to simply copy foreign technology and still have successful business inside Brazil.

The first informatics law is one example of the overall Brazilian posture for industrial development adopted over the second half of the 20th century. According to Averbug (1999), the period between 1957 and 1988 "was characterized by protectionism attached to the politics of import substitution (especially in the 1970s, due to the oil crisis)" (p. 46), through tax barriers and other instruments such as the first Informatics Law. Although nuances of specific economies and industries need be taken into consideration, as well as the time horizon, authors such as Lenway, Morck, and Yeung (1996) and Akcigit, Ates, and Impullitti (2018) have shown that protectionist policies have the potential to negatively impact R&D&I performance of the private sector, especially in the medium to long term.

All the while, during the Brazilian protectionist period, government incentives for R&D&I in private companies have received little to no attention. This stands in stark contrast to the literature on innovation, which constantly emphasizes that governments play a critical role in strengthening the levels of R&D&I performed by the private sector. According to Negri and Lemos (2009), "financing R&D in companies is one of the universal instruments most utilized to induce technological development" (p. 5). Even further, the Triple Helix model (Etzkowitz and Leydesdorff, 2000) emphasize that

governments play a role in incentivizing the connection between academia and the private sector in order to strengthen innovation through scientific research. The literature would therefore seem to suggest that the posture of the Brazilian government during most of the 20th century was inadequate to ignite R&D&I performed by private companies. Granted additional factors other than government policies (or the lack thereof) most likely contributed to this, but indeed according to Matias-Pereira and Kruglianskas (2005), Milanez (2007), and Melo (2009), the Brazilian industry has, for the most part, operated by absorption of technologies developed elsewhere, which crippled the need for R&D capacities in the private sector.

“...in Brazil, the sectors which possess the most significant commercial deficits, are, in general, characterized as being knowledge intensive, i.e., sectors in which R&D investments and professional qualification are critical success factors for competitiveness” (Milanez, 2007, p. 126)

The scenario of economic protectionism and little attention to policies and programs oriented towards promoting private R&D and innovation started to transition relatively recently, from the 1990s onwards. According to Garcia and Roselino (2004), the first informatics law, along with other protectionist policies largely adopted in Brazil prior to the 1990s, was dismantled due to a “change in posture of the Brazilian government in face of the offensive national and international pressures” (p. 172). Protectionist policies were changed into fiscal incentive policies, and alterations have been made to the levels of import taxes. With a change in posture towards industrial development in the 1990s, the country gradually turned its attention to public policies for R&D&I incentives, one of the tools applied as alternative to the earlier protectionism.

An early example was the second iteration of the Informatics Law (1991), which was based on tax incentives for R&D investments made by informatics-related companies operating and headquartered in Brazil. In summary, the main aspects of this policy provided: (1) exemption from the Tax over Industrialized Products (IPI) up until the year of 1999, and (2) up to 50% reduction on the Income Tax, by directly deducting expenditures made on R&D (after the expenditures had already been accounted for in operational expenses). Departing from the *national substitute* instrument of the first Informatics Law. The Informatics Law was later altered in 2001, introducing new incentive instruments, the main ones being: (1) national products would be given preference on government purchases, (2) requiring that outsourced R&D be performed by certified institutions, and (3) incentives for outsourced R&D

investments with institutions located in less developed regions of the country (commonly universities and public research institutions). The changes observed from the first Informatics Law to its third iteration greatly showcase a shift towards R&D&I incentives as one of the substitutes for protectionist policies.

A number of important policies with similar objectives surfaced in Brazil over the last two to three decades. In the 1990s, apart from the new Informatics Law mentioned above, two of the most important introductions were the Program for Technological Capacitation of the Industry and Agriculture (PDTI/PDTA) in 1993, and the Sectoral Funds, starting in 1999.

Under the 1993 Program for Technological Capacitation of the Industry and Agriculture (PDTI/PDTA), private companies engaging in R&D activities could receive tax reductions based on the amount of investment made on research and development on a given fiscal year. However, PDTI and PDTA ended up underperforming due to intrinsic flaws, the most important of which perhaps were bureaucratic barriers: PDTI and PDTA required that companies would submit projects for anticipated approval, in order to qualify each individual project for tax benefits. From 1994 to 2005, only 179 companies participated and were granted tax benefits under these programs (Kannebley Jr., Shimada, and Negri, 2016, p. 113). Notwithstanding the low performance of PDTI and PDTA, the introduction of these policies drew the direction towards which Brazil would follow on its policies for transversal R&D&I incentives. Over one decade later, in 2005, PDTI and PDTA were substituted by a new policy named “Lei do Bem” (lit. “The Good Law”) through the Federal Law No. 11.196 (Brazil, 2005b). Called “GL” here, for short, from now on. GL has eliminated the bureaucratic step of pre-approving R&D projects that was present in PDTI/PDTA, and has thus been more effective in terms of attracting a higher amount of companies to participate. According the last available report, 1008 companies across the entire country benefited from GL in 2014 alone (MCTIC, 2015), up from 130 in 2006. GL not only incorporates tax benefits in the form of (additional) deductions of R&D expenses before tax calculations, it also increases the amount deducted for companies that have a higher number of full-time researchers employed than in the previous year, and for those that have issued patents, along with other benefits. Overall, GL has been more effective than the previous PDTI and PDTA in terms of number of companies benefited and volume of tax weaving provided, for it is less bureaucratic and offers a bigger array of incentives.

Kannebley Jr, Shiamada, and Negri (2016, p. 140) noted that although the impacts of GL are positive, further developments in this direction were still necessary. For instance, providing incentives based on R&D increments (as opposed to total), and articulating mechanisms to reduce costs of R&D production capital (as opposed to subsidising costs).

The Sectoral Funds were introduced in 1999 into the structure of the old National Fund for Scientific and Technological Development (FNDCT). Although FNDCT was established in 1969 as a fund “whose aim is to finance innovation and national scientific and technological development” (MCTIC, 2012, p. 4), the original FNDCT “lacked a stable source” of investments (p. 4), and had modest impact on the private sector, have being much more relevant to public universities and research institutes. In 1999 the new Sectoral Funds for science and technology were established and incorporated into the structure of the old FNDCT. Each Sectoral Fund was to have its own multiple financing sources, for instance, from royalties and other contributions stemming from the exploration of natural resources, part of taxes received by the government over industrialized products - in varying degrees -, contributions from companies which take part in fiscal incentive policies, licensing, etc. The sources of each fund are matched to specific sectors of economic activity. In total, there are 15 funds, 13 of which are vertical (sector specific), and two are transversal (activity-specific). The Sectoral Funds originated with the Petroleum Law of 1997 (Brazil, 1997) which mandated the creation of an oil & gas fund to finance science and technology development in this area, the fund became effective in 1999 and was the first Sectoral Fund to exist. In the immediately following years, similar funds were created for sectors such as Energy, Aeronautics, Mining, Biotech, Informatics, and more.

Gomes et al. (2015) observe that before the Sectoral Funds, Brazilian policies towards science and technology followed a linear model of innovation, “which stamped the Brazilian reality with an asymmetry, with good academic indicators, but fragile indices regarding private Research and Development (R&D)” (p. 353). According to these authors, the Sectoral Funds were an active attempt at incorporating a systemic concept of innovation, represented by the cooperation and coordination of universities, research institutions and the private sector. While the Sectoral Funds can be applied for isolated projects of universities, research institutions, and private companies, the main goal would be to fund projects made in cooperation between these types of

institutions. However, Gomes et al. (2015) found that, at least for specific sectoral funds, there is an abundance of isolated projects that do not involve cooperation between different types of institutions. Also, the participation in isolated projects may be majorly represented by universities and research institutions: Melo (2009) observed that the Green and Yellow fund was, at the time, the only fund authorized to grant resources directly to private companies, without joint cooperation with universities or research institutes, including venture capital style investment, however, the level of operations done in this modality had been small. Therefore, while one of the main objectives of introducing the Sectoral Funds was to push forward participation of the private sector in R&D&I activities, the instrument has continued to reflect the imbalance between the academic world and the private sector in science & technology indicators that has developed over the last century.

4.2.2.3 Policies for innovation through interactions

Up to now, this section has provided a brief and summarized history of Brazilian efforts done to consolidate (a) scientific research in the academic world and (b) R&D investment in the private sector, from a governmental standpoint. This description is delivered as one fundamental part of the institutional environment surrounding Technology Parks for the purposes of this case study. As observed by Radosevic and Myrzakhmet (2003), the success of Technology Parks depends on the development of the entire innovation system of a country, because Technology Parks cannot make up for deficiencies in the levels of R&D performed by companies and/or academic research, and “innovation policy addresses three dimensions: supply of innovation; demand for innovation; and bridging between them” (p. 12). While Technology Parks lie on the third category, the dimensions of demand and supply are critical for their proper functioning. In terms of the three dimensions described by Radosevic and Myrzakhmet (2003), this section has focused on the demand and offer sides of innovation up to this point, and the third dimension (bridging) was only present as one component of the Sectoral Funds. Next, we will focus on policies and programs specifically aimed towards the dimension of bridging

Up to the 1990s, Brazilian policies and programs have been mostly directed towards developing Science & Technology on the academic side and on the private

sector, separately. This can perhaps be equated to Sábato's Triangle, or the "laissez-faire" model, described as a precursor model to the Triple Helix, which "consists of separate institutional spheres with strong borders dividing them and highly circumscribed relations among the spheres" (Etzkowitz and Leydesdorff, 2000, p. 111). Authors such as Lemos and Cário (2013) suggest that innovation itself was simply not effectively a part of Science & Technology policies in the country prior to the 1990s, alternatively, this can be seen as a different approach to innovation that relied on "outdate" models by some standards (laissez-faire/Sábato Triangle), a linear approach to innovation as opposed to systemic/interactive (Gomes et al., 2015), or a deficiency in attending to all three dimensions of innovation policy in the terms suggested by Radosevic and Myrzakhmet (2003).

Regardless of which description is used, the fact is that the 1990s saw a change in Brazilian posture towards science, technology, and innovation policies and programs, especially with the introduction of the Sectoral Funds, when attention was given to interactions between the private sector and the academic world. Such interaction was not completely absent from strategic plans in the country before the 1990s, for instance, the very first version of the Basic Plan for Scientific and Technological Development (PBDCT), for 1972-1974, already mentioned such interactions as strategic goals to be achieved. However, although awareness of the subject did in fact exist, not much was realized in terms of concrete policies and programs aimed at such. The most concreted example, prior to the 1990s, could be CNPq's 1984 program for the creation of Technology Parks (Anprotec, 2008), where new Technology Based companies would be created and hosted inside newly created parks, transferring knowledge from universities and research institutes into the productive sector (Almeida, 2016, p.35). This initial effort could not achieve the objective of establishing lasting Technology Parks in the country, but some of the projects initiated within the scope of this program resulted in the creation of the first business incubators in Brazil, attached to public universities.

The late 1990s, in addition to the Sectoral Funds (already mentioned before), saw the creation of the National Program for Supporting Business Incubators (PNI), one of the initiatives created in the realm of the 1992 National Program for Supporting Industry's Technological Capacitation (PACTI). PNI was established to allow public funding of diverse types of projects demanded by business incubators and their

resident companies, where most of the money comes from the National Fund for Scientific and Technological Development (FNDCT) and one of the transversal Sectoral Funds (“Green-and-Yellow”). PNI was finally fully operationalized in 2002, and in 2005 it had its scope expanded to include Technology Parks (remaining the old acronym, PNI).

In the 2000s, the major piece of policy was the 2004 Innovation Law. The Brazilian federal law No. 10.973 of December, 2004 (Brazil, 2004), also known as the Technological Innovation Law (Almeida, 2008), or simply the Innovation Law, has been labelled “the landmark of technology transfer and academic entrepreneurship in Brazil” (Dalmarco, Hulsink, and Blois, 2018, p. 105) and “the legal landmark of innovation in Brazil” (Rauen, 2016, p. 23). It was first regulated in 2005, through the regulatory decree No. 5563 of October 2005 (Brazil, 2005a; Garnica, Oliveira, and Torkomian, 2006, p. 2). It “contemplates incentives to innovation and to scientific and technological research in the productive environment” (Brazil, 2004). Matias-Pereira and Kruglianskas (2005) describe the objectives of the Innovation Law as divided in three axes:

“The Technological Innovation Law is oriented to: the creation of a favourable environment to the establishment of strategic partnerships between universities, technological institutes and companies; encouraging the participation of science and technology institutions in the process of innovation; and spurring innovation inside companies.” (Matias-Pereira and Kruglianskas, 2005, p. 11)

This piece of policy was heavily influenced by similar innovation policies implemented elsewhere, especially the Bayh-Dole Act in the USA (1980) - granting universities the right to patent results from publicly funded research -, and the French innovation act of 1999 - incentivizing university-industry interactions in research, for instance, by sharing laboratories and developing joint research (Matias-Pereira and Kruglianskas, 2005; Rauen, 2016). Following the trend observed by Mowery and Sampat (2005) of countries emulating innovation policies that have been deemed successful in other economies. Like in France, where the Loi Allegre “introduced a number of provisions that went well beyond intellectual property” (Malva, Lissoni, and Llerena, 2013, p. 217), the Brazilian Innovation Law also had a broader scope than the American Bayh-Dole Act, not focusing solely on patents and licensing. The Innovation Law, among other things: allows companies to be incubated inside public spaces (public universities and research centres), allows the sharing of infrastructure,

equipment, and human resources between public and private institutions (for technological development goals), authorizes financial resources to be invested directly into companies from public universities (conditioned to it being specifically for innovation projects, and having a defined compensation), and more (Matias-Pereira and Kruglianskas, 2005, p. 12).

Over a decade later, in 2016, the Brazilian government introduced the “New Legal Landmark of Innovation” as an update to the 2004 Innovation Law. Attempting to fix issues identified with the original Innovation Law (Rauen, 2016) and to address the interdependencies between multiple legal instruments that have affected the intentions of the original Innovation Law.

“The new legal landmark of innovation, known as the Science, Technology and Innovation Code, has been approved in January 11, 2016 (...). The new policy is the result of a nearly five year long process of discussions between actors of the National Innovation System (NIS), in the helms of the Brazilian Science and Technology Commission of the Chamber of Deputies and the Senate. These discussions had as a starting point the recognition and necessity to change matters of the Innovation Law and other nine policies related to the theme, aiming at reducing legal and bureaucratic obstacles and granting better flexibility to actor institutions of this system.” (Rauen, 2016, p. 21).

One example of shortcomings addressed by the new legal landmark of innovation was operationalizing a mechanism through which public universities and research institutes could receive and appropriate financial compensations from private companies. The original Innovation Law allowed the reception of financial resources by public universities from private companies, but lacked any description of how this was supposed to be put to practice. An attempt to solve this was made in 2014 through a policy that established a mechanism for financial resources to be received, but that mechanism transferred the money to the National Treasury, meaning that universities did not appropriate the compensations individually. The new landmark of innovation provided a much-needed mechanism to solve this issue, allowing funds received from private companies to be kept by the individual university (conditioned to the money being applied in future innovation-specific activities). The shortcomings addressed by the 2016 update to the Brazilian legal innovation framework have had much to do with legal uncertainty created by the 2004 Innovation Law. Especially considering public universities, the themes addressed by the original Innovation Law intersected in many points with topics regulated by multiple other pieces of legal instruments, notoriously

with laws that rigidly control the management of public entities in Brazil, resulting in multiple points of legal uncertainty. In turn, public universities may tend to be conservative and avoid points of legal uncertainty, resulting in underutilization of the legal instrument (Rauen, 2016). Although improvements were made with the 2016 update, Rauen (2016) had already identified, however, that the new policy still let some open gaps:

“Despite advancements conferred by these alterations to the original text of the Innovation Law, some legal uncertainty aspects remain, such as: i) the operationalization of mechanisms through which researchers involved in service providing and partnership agreements for technological development can receive additional remuneration and scholarships; ii) the way in which companies can be granted access to intellectual capital of Scientific-Technological Institutions; and iii) the ways in which Scientific-Technological Institutions should proceed in order to ensure equality of opportunities to companies interested in accessing their infrastructure. These matters could keep these mechanisms underutilized” (Rauen, 2016, p. 33)

While the innovation law finally allowed some of the most important mechanisms for interaction between public universities (and other public research institutes) and private companies, universities were delegated the responsibility to develop internal policies in order to decide upon the operationalization of interaction mechanisms allowed by the law. For instance, sharing laboratories with private companies is one of the interaction mechanisms described in the legal framework, however, universities need to regulate the rules for such interaction with an internal innovation policy before it can be properly utilized. The effects of this new landmark of innovation remain to be seen and studied by the literature, giving the very recent nature of the matter.

In the realm of public instruments for university-industry interactions in the 2000s and 2010s, the first Innovation Law and the 2016 update are the main efforts realized in the country, though some adjustments and complements have been done over the years, these are the major landmarks. Perhaps another worthy mention is the creation of the Brazilian Company for Industrial Research and Innovation (Embrapii), in 2013. In a nutshell, Embrapii arose out of demand from an association of industry representatives which was acknowledged by the Ministry of Science and Technology. The model consists in providing credentials for “Embrapii units” to be created inside universities and research institutes, which can perform research projects demanded by companies in the knowledge areas each specific unit has been certified for. Embrapii has established contracts with the Brazilian Ministry of Science, Technology

and Communications (MCTIC), and the Ministry of Education (MEC), through which it receives a budget that is repassed to units according to their demand expectations. Research costs are split as 1/3 paid for by Embrapii, 1/3 paid for by the demanding company, and 1/3 is covered by the university or research institution that houses the Embrapii unit, however the 1/3 covered by the host institution is economic, but not financial, that is, it is represented by the personnel, research equipment and infrastructure to be utilized during the project. The main advantage of Embrapii is to financially dilute risks associated with R&D, commonly high due to uncertainty.

4.2.2.3 Impacts

In summary, we have observed that the Brazilian has indeed applied policies to (a) increase the levels of scientific research in the academic world, (b) increase the levels of R&D performed by the private sector, (c) provide incentives for the private sector to demand interactions with universities and research institutes, and (d) create tools to allow and facilitate the aforementioned interactions. The table below summarizes the public programs, policies and entities mentioned in this brief description:

Table 4 – Main public policies, programs and entities for Science, Technology, and Innovation

Year	Public instrument
1951	Creation of CNPq and CAPES;
1961	first Directives and Basis for Education (LDB);
1965	Report No 977: formal consolidation of graduate programs and degrees;
1969	Creation of FNDCT;
1971	FINEP is responsible for managing FNDCT;
1972	First Basic Plan for Scientific and Technological Development (PBDCT);
1984	The first informatics law; CNPq's program for Technology Parks;
1985	Ministry of Science and Technology was created;
1991	Second Informatics Law;
1992	National Program for Supporting Industry's Technological Capacitation (PACTI);
1993	Technological Capacitation of the Industry and Agriculture (PDTI/PDTA);

1994	Law of Support Foundations (Fundações de Apoio);
1997	The Petroleum Law;
1999	The first Sectoral Fund;
2001	Third Informatics Law;
2002	PNI is operationalized;
2004	First Innovation Law;
2005	PNI incorporates Technology Parks; Lei do Bem ("The Good Law");
2013	The Brazilian Company for Industrial Research and Innovation (EMBRAPPI) was created;
2016	New Legal Landmark of Innovation (second Innovation Law)

Source: created by the author

It was observed that Brazil has continuously sought the development and expansion of scientific capacities in universities and research institutes through public instruments. These produced positive results, and to this day academic output in Brazil continues to grow: In 2000, Brazil accounted for 1.14% of the world's scientific publications, and 44.15% of Latin America's. In 2017, those numbers jumped to 2.63% and 52.47%, respectively (SCImago Journal & Country Rank, accounting for journals indexed by Scopus).

While Brazilian research output and availability of qualified human resources for research has increased manifold over the years, these have been mostly concentrated inside public universities and public research institutes. Research production inside companies and a connection between the private sector and public universities for scientific purposes has, on the other hand, struggled to evolve. While government efforts to promote science inside universities and public research institutions has a long history (that was briefly mentioned here), real incentives for private companies to engage in research is a much more recent event, and even more are policies and programs to connect the academic and productive worlds. The stark contrast between engagement in research of public universities and research institutions versus private companies in Brazil can be seen in the two indicators below. The first indicator is the number of researchers employed by the government in comparison to private businesses and non-profits:

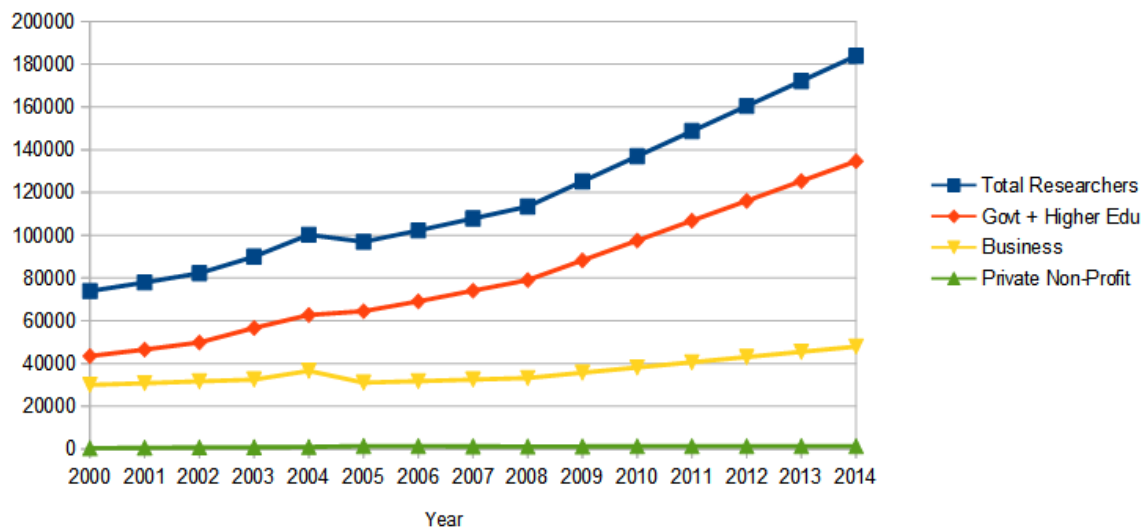


Figure 10 – Number of Researchers per sector of employment (Full time)
Source: The United Nations Educational, Scientific and Cultural Organization (UNESCO)

The second indicator is the participation (%) of private businesses in financing total Gross Domestic Expenditure on R&D (GERD) for Brazil and other countries as a comparison:

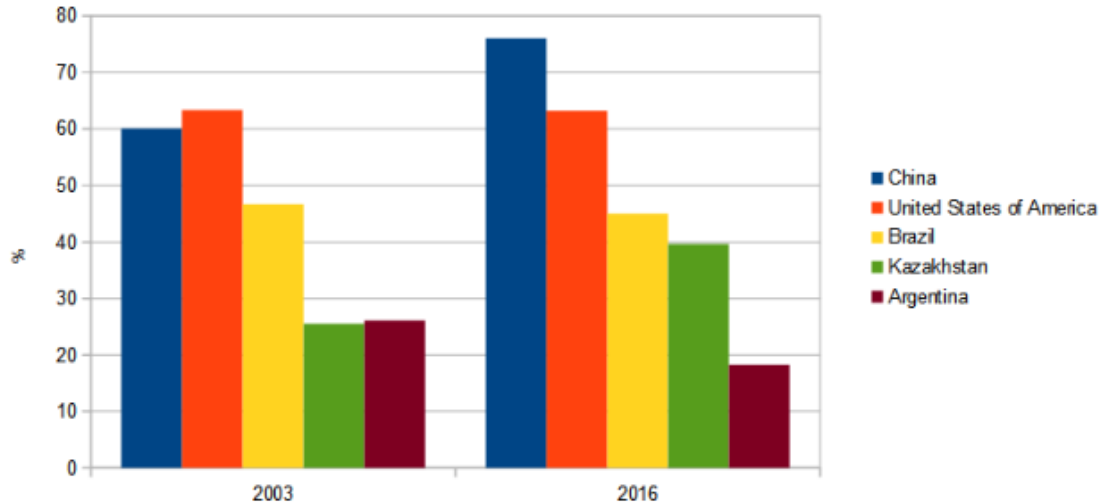


Figure 11 - % of GERD financed by business enterprises.
Source: The United Nations Educational, Scientific and Cultural Organization (UNESCO)

Steiner, Cassim, and Robazzi (2008) noted that “In developed countries, out of every four researchers, three are in companies and one in academia. In Brazil, on the contrary, out of every four researchers, three are in academia and one in a company” (p. 6). Furthermore, the literature generally shows that nations, which display higher levels of scientific and technological development have the private sector being

responsible for most of the investments in R&D. Whereas, in Brazil, participation of business financing in R&D has constantly remained below 50% of GERD, with the exception of 2005, when it reached its peak at 50.43%.

The Industrial Survey of Technological Innovation (PINTEC), published by IBGE for the first time in 2003 – when PTEC-UFRJ was officially inaugurated -, set the overall innovation rate for the Brazilian industry to be at 33%, years later, in the last available version of the research (2014), innovation rate sat around 36%. While government incentives are key to spur private R&D&I, the survey showed that only 6.21% of companies received any kind of government incentive for innovation activities.

Finally, although many positive results have been achieved through the policies and programs mentioned throughout this section, both private and public R&D in Brazil, jointly, have constantly remained below the world's average, and especially low when compared to developed and technologically advanced nations. Figure 12 below shows that, to this day, Brazil still lags behind in key indicators such as R&D investments (public and private) as a % of GDP:

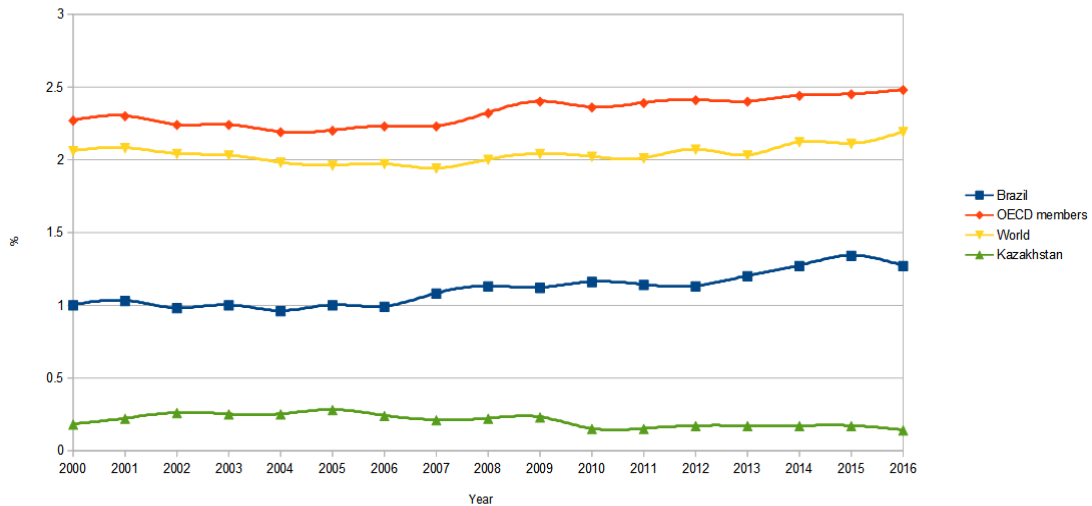


Figure 12 – R&D expenditure (% of GDP)
Source: World Development Indicators (WDI) - World Bank

In general, these numbers would indicate a challenging environment for Technology Parks to thrive in. It is important to consider that other factors might isolate a given Technology Park from the overall outlook of the innovation system in a country. In Brazil, specific sectors such as oil & gas, agrobusiness, and aerospace are positive outliers in that R&D&I levels have historically been strong and global-class competitive. Actually, interactions between universities or public research institutions and the private

sector have also notoriously developed earlier and stronger, in addition to extensive academic expertise being available (either distributed across the board or concentrated into specific universities and/or research institutes). Technology Parks that may happen to be dedicated to, or otherwise stronger, in these outlier areas can therefore enjoy a much less challenging environment in terms of demand and offer for their matchmaking process. One characteristic shared by the three aforementioned sectors is that one key organization has led the development of the sector almost single-handedly, Petrobras for oil & gas, Embrapa for agrobusiness, and Embraer for Aerospace (all three companies originated as government-held companies). The Technology Park chosen for this case study, PTEC-UFRJ, has indeed developed stronger capabilities around one of these sectors (oil & gas) and it happens to be linked to a university that has historically enjoyed close relationships with Petrobras for R&D&I purposes. This seems to suggest that PTEC-UFRJ would have enjoyed much better environmental conditions than the overall outlook of the Brazilian innovation system presented here. To understand the importance of Petrobras' R&D&I activities and their relationship with UFRJ to the development of PTEC-UFRJ, the next section will provide a brief historical account of Petrobras' R&D-related events most relevant to UFRJ and the Technology Park.

4.3 Petrobras Research & Development

During the process of collecting information about the PTEC-UFRJ, it became clear from the beginning that Petrobras played a decisive role in the growth process of the park. This section will explore relevant details regarding Petrobras' Research & Development system and its long-time relationship with UFRJ, as well as historical details of the pre-salt rush, arguably the single most impactful event that resulted in PTEC-UFRJ's extensive growth over the last decade. This is the last item in the description of PTEC-UFRJ's environment. The next section will delve into the history of PTEC-UFRJ itself.

4.3.1 CENPES

The Leopoldo Américo Miguez de Mello Research and Development Center (CENPES) was established by Petrobras in 1963, originally located at the Praia Vermelha neighbourhood, Rio de Janeiro - RJ. CENPES was born out of Petrobras' Center for Training and Research in Oil (CENAP).

In 1952, the National Petroleum Council (CNP) had created an educational program for developing human resources in the field of oil refining (as an specialization for engineers). This was later transferred to be under Petrobras' responsibility in 1955 (Leitão, 2004), shortly after, other specialization programs offered to general engineers and chemistry bachelors began to be structured under the consolidated figured of CENAP. These efforts were due to the notorious lack of qualified professionals to work in the field available at the time - Leitão (2004) claims that, during those years, around 80% of engineering degrees in Brazil were granted in the field of civil engineering, while chemical engineering programs had just started to exist.

CENAP's main program, Oil Refinery, was located inside the Federal University of Rio de Janeiro (UFRJ) campus at Praia Vermelha, for which a dedicated building was erected. Some programs were conducted in partnership with this university, but partnerships to other universities were also established. For instance, production engineering programs were conducted in the city of Salvador - BA, in partnership to the Federal University of Bahia, and a program in equipment maintenance was offered in partnership to the Aeronautics Technology Institute (ITA) (Leitão, 2004).

CENPES was born in 1963 to promote Petrobras' research and development capabilities, shifting from a sole focus on technical training of human resources. It incorporated 67 employees from the "old CENAP" (Lima and Silva, 2012, footnote, pp. 99-100). That was the same year in which UFRJ's Master's in Chemical Engineering program was implemented, led by UFRJ's professor Alberto Luiz Coimbra (who was also teaching at CENAP's oil refinery program). An effort that became the root of UFRJ's graduate school of engineering (COPPE).

Initially, research was focused on developing technologies related to oil refinery. In 1973 CENPES was moved to the UFRJ campus located at the Fundão Island, where it remains to this day. In 1974 the Garoupa oilfield was discovered by Petrobras, the first commercially sized oilfield to be found in the offshore basin of Campos - the basin spans around 100 thousand square kilometres from the north coast of Rio de Janeiro state to the south coast of Espírito Santo state. Because of this, CENPES expanded

research into Exploration and Production (E&P) technologies during the 1970s. In 1976 and 1983, respectively, basic engineering in oil refinery and E&P have been included into CENPES' activities. During the 1990s, some research began to be conducted in the fields of gas, energy, sustainable development, and biofuels, which have been officially incorporated to CENPES' activities as of 2002 (ANPEI, 2013).

Besides conducting research, development, and basic engineering activities internally, CENPES is also responsible for articulating partnerships with other institutions for research and technological development. According to Lima and Silva (2012), national expertise in the sector was for a while concentrated inside CENPES, and:

“The university contributed indirectly through training many generations of generalist technicians, not explicitly tied to the sector. It was only in the second half of the 1990s, when state monopoly over oil & gas was broken and a new regulatory framework was created, that a bigger opening happened, in fact, from petroleum companies to the external scientific community. So ‘barriers between the scientific community and the petroleum sector began to be overcome. The university started to be inserted, competently, in generating personnel and in the technological development of the oil and gas sector” (p. 100)

Still according to the same authors, CENPES established a number of partnerships to multiple universities in the country, but they highlight that the relationship established with COPPE/UFRJ is surely the closest relationship of that type. They interviewed COPPE's then Technology and Innovation Director, Segen Farid Estefen, which acknowledged the physical proximity as one of the deciding factors for this successful long-term partnership. According to the authors:

“...if there exists, today, in Brazil, successful experiences of something similar to the so called innovation system, proposed by the specialized literature as the most propitious way to promote technological change, this continuous interaction between universities, Petrobras, and the Brazilian government surely is one of its best examples.” (p. 101)

Lima and Silva (2012) also note that, due to the first oil crisis (1973) and an increasing demand by growing sectors of the Brazilian industry, collective efforts went on the direction of developing national production capabilities and gradually move away from the dependence on imported oil. Because of that, starting in the 1970s, a higher emphasis was put on E&P, instead of refinery capabilities relying on imported oil. This trend lasted long-term, for instance, 57% of R&D expenditures from 2008 to 2010 have been directed to E&P.

Leite (2005 apud Silva and Lima, 2012) observe that two main challenges had to be faced by Petrobras in order to move away from import dependency: (1) developing refinery technologies able to deal with lower quality petroleum. Since national refining capabilities had evolved around higher quality imported petroleum, while Brazilian petroleum was showing itself to be generally heavier/lower quality. And (2) developing technologies for “Ultra-deep Waters” (UDW) to extract oil from the offshore Brazilian basins (p. 103).

Lima and Silva (2012, pp. 103-105) provide a great summary of relevant events from the 1990s-2000s, listed below:

- (1) In 1997, government monopoly over the exploration of the oil and gas sector was officially removed through the constitutional amendment No. 9 of 1995 (Viana, 2012) and the Federal Law No. 9478 (known as the Petroleum Law). A monopoly which had been in place since 1953, when the Federal Law No. 2004 established the creation of Petrobras as a government-held company, prescribing that the Brazilian federal government should at no point possess less than 51% of voting shares; Government ownership over the natural reserves was kept, as observed in the constitutions of 1934, 1967, and 1988, however, concessions for private companies to work on E&P became allowed;
- (2) The Petroleum Law also established the creation of the National Petroleum Agency (ANP), to be responsible for regulating and supervising the sector;
- (3) In 1998, the first Sectoral Fund was established, directed at the Oil & Gas Industry (CT-Petro). Collecting funds to be applied in non-profit research and education institutions, tied to projects in this specific sector. The fund was to be managed by FINEP and CNPq;
- (4) In 1999, ANP launched the Program for Human Resources in Oil & Gas (PRH), to fund research, scholarships, infrastructure for classrooms and laboratories, and to attract visiting researchers, spreading expertise to outside Petrobras;
- (5) After the attacks to the World Trade Center, in 2001, with the subsequent Iraq War, there was a spike in oil prices, which turned the sector to be extremely profitable. Brazil leveraged this by establishing long-term relationships with emerging countries which had high demand for oil in the following years. Also, internal policies were put in place with the aim of increasing internal demand, such as “the policy for massification of vehicle use” (p. 104). According to the

authors, these events “shielded the trade balance, and also allowed the country to overcome the 2008 financial crisis” (p. 104);

- (6) In 2006, ANP set forth a new rule forcing oilfield operators in Brazil “to invest at least 1% of gross revenues, made through new highly productive oilfields, in Research and Development”. Half of it to be internal investments to the companies, while the other half should be invested in Scientific and Technological Institutions in Brazil (p. 105);

According to Viana (2012), among other responsibilities, ANP was delegated by the Federal Government to be responsible for granting concessions to private companies wanting to perform economic activities in the sector. Concessions were to operate as grants to explore specific “blocks” defined by ANP, where the private company takes full responsibility for the risks involved, and pays a “subscription bonus” for the right to explore. If oil is found, the company gains the ownership to the extracted product, subsequently complying with the payment of royalties, government shares, and taxes (pp. 171-172).

Lima and Silva (2012, p. 102) claim that Brazil reached a “self-sufficiency” status for internal oil demand at the year of 2006. According to a report by Reuters (2007), in 2007 Petrobras was producing “around 1.8 million barrels of oil a day, satisfying Brazilian internal demand” but still having to import “light” oil to mix in with the Brazilian generally heavier oil, for refining purposes. Because “by international standards, the closer it gets to 50 API degrees, the higher the oil quality is. In Brazil, the majority of petroleum produced is heavy, varying between 18 and 22 API degrees” (Luna, 2007), while the international benchmark “Brent” oil sat around 32 API.

4.3.2 Oil in the pre-salt layer

In 2006, Petrobras began analysing the “pre-salt” layer for potential oil reserves. In October that year, Petrobras communicated to ANP that light oil had been found in the pre-salt layer around the Santos Basin (Petrobras, 2007, p. 11, p. 23; Luna, 2007). The Santos Basin spans around 350 thousand square kilometres offshore from the north coast of São Paulo state to the north coast of Rio de Janeiro state, where it meets the Campos Basin.

The company continued to inspect potential pre-salt reserves throughout 2007, having found a small reserve in the Campos Basin, along the coast of Espírito Santo state, in June that year. Finally, a major reserve was found in the “Tupi” area of the Santos Basin, 320 kilometres offshore of Rio de Janeiro state. Petrobras estimated “a reserve between 5 and 8 billion barrels of oil in deep waters” (Petrobras, 2007, p. 6). To put it into perspective, at that point, just before this new discovery, the entire “proved reserves” of oil in the country were estimated to be around 12 billion barrels (Reuters, 2007). Furthermore, according to Petrobras’ 2007 annual report (p. 27), the pre-salt oil was deemed to be “excellent quality light oil”. Reuters (2007) reported that the newly found oil sat around 28 API degrees. In the following years, further appraisals have been made to evaluate Tupi’s size and commercial potential, along with exploration to find new reserves. In December, 2010, Petrobras announced that the Tupi oilfield, along with another closely located field, named Iracema, were deemed to be commercially viable, holding 8.3 billion barrels in total, 6.5 billion belonging to Tupi, the biggest oilfield to date ever found in Brazil. Upon announcement, the fields had their names changed: Iracema was nicknamed “Cernambi”, while Tupi was nicknamed “Lula”.

According to Lima and Silva (2012, p. 104), Petrobras had estimated that the new reserves would bring national production from 2.1 million barrels a day (as of 2010), to 6.1 million barrels a day in 2020. This expectation didn’t quite materialize: As of January 2020, ANP announced national production to be just above 4 million barrels a day, 66% of which being extracted from the pre-salt layer.

Nevertheless, the good prospects for the company brought strong investments by Petrobras into CENPES and a strong financial circulation into the entire oil-related

innovation system through the billionaire sectoral funds (Lima and Silva, 2012, p. 104). Innovation efforts here became even more critical for the future of the company, which stated: “The novelty of the finding - such depth has never been commercially exploited - reaffirmed our tradition of technological excellence and opened a new exploratory horizon for the Company and for Brazil...” (Petrobras, 2008, p. 6). In 2007, Petrobras invested 1.044 billion BRL in R&D, growing 10% from the year before, during which year CENPES kicked-off research related to key strategic areas:

“In 2007 Cenpes started two new technology programs related to sustainability of the Company, namely: the Technological Program for the Development of Pre-Salt, focused on this new geological boundary, and the Technology Program for Mitigation of Climate Change, established to develop technologies to lessen the influence of the activities and products of Petrobras in global climate change.” (Petrobras, 2007, p. 53)

All the while keeping R&D activities in areas which CENPES had been developing expertise for years before the pre-salt was found, such as biofuels:

“Petrobras put Brazil in the global vanguard of second generation biofuels (produced from agro industrial residues such as sugar cane bagasse). In 2007, the first pilot plant for bioethanol (ethanol from lignocellulose) came into operation in Cenpes with enzyme technology (process that consists of the breaking of molecules through the action of enzymes). A semi-industrial plant is scheduled to 2010” (Petrobras, 2007, p. 53)

According to Viana (2012), in 2010, the Federal Law No. 12351 established a new framework for the participation of companies other than Petrobras in E&P activities related to the pre-salt, namely the “sharing system”. For all other E&P activities not related to the pre-salt, the older concession system remained in place. The author compiled a list of the main rules set forth by the new framework (p. 174):

- (1) For each E&P concession, the participating companies had to hand-in to the government a specific share of the amount of oil extracted. This share was to be especially defined for each offer;
- (2) Petrobras was granted a minimum compulsory participation of 30% in any block concession acquired by other companies through bids;
- (3) Petrobras should be able to compete with other companies in bids in case it wished to possess more than 30% (allowed to reach 100%) participation in any specific block;
- (4) The government should be able to directly contract Petrobras without going through bids;

As part of the new framework, a new government company was established, named Pré-Sal Petróleo S.A. (PPSA or Petro-Sal), to be 100% owned by the Federal Government. The main role of the new company was to represent the interests of the Federal Government in the consortia which would explore the pre-salt. PPSA was not to be part of the actual operations in E&P, rather, it was conceived to act solely as an investor in the consortia, thus, holding the power to participate in decision-making (Viana, 2012).

The new framework was subject to major backlash from various sources. The changes had been mostly supported on the basis that the pre-salt offered much lower risks and higher gains than the previously found reserves, and that Petrobras had preference due to being the discoverer and having the capacities to explore the new reserves by itself in case it wished to. Viana (2012) compiled examples of the main criticisms to the new framework, which I superficially and non-comprehensively summarize below:

(1) going against the constitution, which in its article No. 173 prescribed that “mixed capital” companies (jointly owned by the government and private investors, such as the case of Petrobras) should not possess legal privileges which are non-attainable for private companies. As the government is not the sole stockholder of Petrobras, a select few private investors have supposedly been granted a benefit which is not attainable by any other private company,

(2) going against the objectives of the 1997 Petroleum Law and other policies undertaken in the 1990s to end the oil monopoly and protectionist policies in general, all the while increasing legal uncertainty to private companies and investors, under the argument that they could not rely on legal instruments to *at least* not put them in a worse off condition than what was previously granted by the legislature, and

(3) taking away responsibilities and reducing the degree of control attributed to ANP. When created, in 1997, ANP had been heavily praised for taking away direct government powers over regulation and control in the sector, acting as a “neutral” mediator which could be better trusted by private companies to not be biased and fast changing under political influences, according to Viana (2012):

“In practice, the most important decisions relating to the selection of companies, definition of blocks, and management of contract execution will be held by Petro-Sal, not by ANP. The important difference between them is that ANP has been conceived to be an autonomous regulatory entity relative to the

government, while Petro-Sal is an arm of the government itself, subject to political determinations of the government.” (p. 188)

Regardless of the criticism, the new framework has remained mostly in place since its inception. The biggest change to it happened through the Federal Law No. 13365 of November 2016, where Petrobras’ participation in the exploration of every block was made preferential instead of compulsory. Under the new rules, Petrobras would have up to 30 days to decide if it wishes to get a 30% share (or higher) over new block offerings (Brazil, 2016b). These changes became effective as of May 2017, when the Federal Regulatory Decree No. 9041 was sanctioned, operationalizing the new rules.

Despite the controversy, Petrobras at the time enjoyed great financial prospective for its future due to the pre-salt findings. In 2010, it concluded the expansion of CENPES, making it the largest research centre in the southern hemisphere (Petrobras, 2010, p. 55), a project which had been in the “freezer” for over 30 years (PETRO & QUÍMICA, 1989 apud Lima and Silva, 2012, p. 107). The expansion was justified “to meet its technological needs, particularly in relation to pre-salt projects”. Reuters (2012) reported that the company had planned to invest 224 billion USD from 2011 to 2015, to be spread among different oil & gas activities.

4.3.5 Impacts on UFRJ

According to Lima and Silva (2012, pp. 105-106), Petrobras’ momentum was responsible for attracting 15 multinationals to start operating inside UFRJ’s Technology Park, seeking to be closely located to CENPES and COPPE, which created a “globally unique cluster related to the sector”. According to the authors, COPPE accounted, at the time, for “50% of all technological projects developed by Petrobras in partnerships with the Brazilian academic community. If you consider UFRJ as a whole [...] this number would grow to somewhere around 70%” (p. 109). COPPE’s then Technology and Innovation Director, Segen Farid Estefen (apud Lima and Silva, 2012), claimed that “around 50% of professors and students linked to COPPE are involved in partnership projects with Petrobras” (p. 109).

The high level of interactions between Petrobras and UFRJ for research purposes can also be observed through ANP’s mandatory R&D investment

clause. Indeed, table 5 below shows that UFRJ has had a high share of ANP's imposed contractual R&D obligations. However, it is important to note that ANP's clause does not affect other oil & gas companies located at PTEC-UFRJ, as it is directed to oilfield operators, all other oil & gas companies linked to the park are service providers and thus do not fall within ANP's clause (BG was the only other operator supposed to be a resident at the park, but the plans did not come to life after its acquisition by Shell).

Table 5 –Total of projects authorized by ANP with financial resources originated from the contractual obligation of R&D investments (2006-2010)

INSTITUTION	Year											
	2006	%	2007	%	2008	%	2009	%	2010	%	TOTAL	%
BRAZIL TOTAL	185	100	171	100	173	100	74	100	110	100	713	100
UFRJ	21	11.6	36	21.1	34	19.7	14	18.9	19	17.3	124	17.4

Source: Lima and Silva (2012, p. 110)

Nevertheless, Lima and Silva (2012, p. 112) put forward some minor negative aspects observed at the time, among which:

- (1) The level of Spin-offs are low for COPPE's capabilities, and it might be the case that students just frequently find it easier to work for Petrobras or other companies in this innovation ecosystem;
- (2) Patent ownership is a controversial subject and is negotiated on a case by case basis (for companies other than Petrobras). Petrobras usually keeps the patents entirely or they share. Prestige universities such as the MIT usually keep the patents;

The authors conclude that, all things considered, the partnership between Petrobras and COPPE had been mostly positive and should provide a very influential example of successful innovation to the country.

5 The Federal University of Rio de Janeiro Technology Park (PTEC-UFRJ)

The Federal University of Rio de Janeiro (UFRJ) has its Technology Park (PTEC-UFRJ) located at the Fundão Island campus, same campus which holds Petrobras' research centre (CENPES, discussed above in section 4.3.1). PTEC-UFRJ was a project lead by Maurício Guedes, who had also championed the creation of COPPE's business incubator in 1994. In reality, COPPE's business incubator was the seed from which the Technology Park came into existence.

[...] one of the fruits [the business incubator] gave us was the Technology Park. The Technology Park is a result from our experience with the business incubator. It was a very ambitious thing at the time [...] (Interviewee N)

During the mid-to-late 1980s, FINEP and the OEA (Organization of American States) funded a project to map innovation environments that existed across Brazil and four other Latin American countries. The Brazilian leg of this project was carried out mostly by COPPE, in partnership with the University of São Paulo (USP). During this time, Maurício Guedes was working in the management of COPPE's NIT (an earlier model of Technology Transfer Office that existed in the university) and as a vice-coordinator of the COOPETEC foundation. Maurício Guedes took the lead in the final stages of the mapping project after the coordinator of COPPE's NIT, who was responsible for the project, left the university to work on the project of a Technology Park that would be created in the city (with the support of the municipal government, a project that ultimately did not succeed). To finalize the project, a closing ceremony was arranged, both to present the results and to network people involved in innovation environments identified during the study. This was the seed for the creation of Anprotec (National Association for Entities Promoting Innovative Enterprises) in 1987, which Maurício Guedes came to preside himself later on during the mid-1990s. His involvement with the study of innovation environments culminated in the proposal for the creation of COPPE's business incubator. UFRJ's higher deliberating entity (CONSUNI) finally approved the construction of a building, inside campus, to be used as a business incubator eight years after the original proposal. Maurício Guedes personally secured the funding for the construction of COPPE's incubator, directly reaching out to representatives of the municipal government to fund 100% of the construction.

While COPPE's incubator had to wait eight years to have the construction of a dedicated building approved by the university, the project had the approval from

UFRJ's dean to kick-off operations in a provisory location. The business incubator quickly generated national repercussion and interest, and pressure for the creation of a fully-fledged Technology Park was felt as a result:

[...] There was already some pressure, upon us, for UFRJ to create a Technology Park. So, at some point, we began discussions of this subject. Actually, the board [CONSUNI] had not approved the incubator yet, but the incubator was super recognized already. It was in the news all the time, it was on Jornal Nacional [TV news program].

Having companies inside universities was a great novelty, so everybody was aware that companies were being born with UFRJ's support. [...] Then we started to think about creating a Technology Park [...] (Interviewee N)

The project for creating PTEC-UFRJ took four years to be approved, unanimously, by UFRJ's board in 1997. The project predicted a total investment of 4.35 million USD for its basic infrastructure implementation in a 350 thousand square metres land area inside UFRJ's campus.

This land area was in a precarious state that demanded much infrastructure investment in order to be usable. In the past, the location where UFRJ has its main campus today, now known as Fundão Island (officially University City Island), was a collection of smaller islands that were joined together via earthwork embankments, forming one bigger island. The particular area of the island where PTEC-UFRJ was to be located had had only been used in the past as a construction site for the Rio-Niteroi bridge, in the early 1970s, and had never been used by the university for any purpose until the construction of COPPE's business incubator in the 1990s and the subsequent Technology Park. The land area was known to be prone to flooding during heavy rains and high tide seasons, and an assessment of the land suggested that either all buildings would have to be elevated, or the entire terrain would need to be raised by two meters in order to be usable. The second option was chosen, and, after securing the funding for infrastructure from the municipal government, 700 thousand cubic metres of earthwork materials were brought to the area, raising its height by two meters.

[...] from an environmental point of view, [it was] very correct. Fundão became a disposing site for construction waste, a very good material for earthworks. Whoever made construction work in the city, during that time, donated pieces of bricks, pieces of tiles, for the terrain [...] (Interviewee N)

As mentioned, upon the approval of PTEC-UFRJ's project, COPPE's business incubator was already present in the land area selected to the TP. In 1997, the incubator was operating at its full capacity (back then) with 12 tenant firms. However,

officially, COPPE's incubator and PTEC-UFRJ are two separated entities, with separate hierarchies and management structures, one not being controlled by the other. Nevertheless, there has always been very tight and "extensive relations" (PTEC-UFRJ, 2016b, p.19), which is natural due to Maurício Guedes' role in the founding of both entities, having remained the coordinator of the incubator and the director of the Technology Park, simultaneously, from their creation until 2015, when he retired from the university.

The COPPETEC Foundation, formally a Social Organization (OS) linked to UFRJ, is one of the foundations responsible for managing contracts, projects, and monetary exchanges between the university and private companies. COPPETEC was made responsible for taking care of contracts and monetary funds related to PTEC-UFRJ, the Technology Park was juridically constituted as one of the projects managed by COPPETEC. UFRJ is a peculiar case among Brazilian universities (as pointed out by one interviewee). Because it had a long history of university-industry interactions much prior to the first Innovation Law (2004), especially in its relationship to Petrobras since the 1960s, the university had already some established practices to mediate and make viable those interactions, one of the mechanisms was, and still is, the COPPETEC Foundation, formally established in 1993 as an evolution of a project management office that existed inside COPPE since the 1970s, the foundation was therefore an already-existing viable solution to manage contracts and funds for both the business incubator and the PTEC-UFRJ upon their creation.

Curiously, one company was already present at the land area of the park upon its creation. At the end of the 1990s, during the very first years of the park, an agreement was made between UFRJ and a Brazilian transportation company named Superpesa, which operates both terrestrial and maritime transport of heavy loads for clients in diverse sectors. Superpesa granted UFRJ the right to occupy a building downtown in the city of Rio de Janeiro, where classrooms and other facilities for the university's music school have been established. In exchange, Superpesa was granted the right to utilize an area located inside PTEC-UFRJ lands, while also paying a monthly rent to the university. Superpesa was somewhat already established in that land area: today's PTEC-UFRJ land was previously utilized as a construction site for the Rio-Niteroi bridge, with Superpesa being one of the companies involved in that project. Afterwards, the company simply lingered there, utilizing the area for some of

their routine operations. However, at this time Superpesa's agreement with the university did not imply contractual obligations with the Technology Park, it was simply an agreement reached for utilizing the land area.

After the earthwork embankment of the land, other essential urbanization and infrastructure construction work were undertaken, preparing the land to receive companies and laboratories. The area was basically deserted - with the exception of Superpesa and COPPE's incubator -, and lacked basic infrastructure such as roads, illumination, etc. These initial infrastructure investments were made by the Rio de Janeiro municipal government, convincing the latter that a successful Technology Park could bring numerous benefits to the city. The initial infrastructure was completed in 2003, when the park was officially inaugurated.

Upon its inauguration, the TP counted with a laboratory for simulating the oceanic environment, such as waves, wind conditions, and underwater currents, being the deepest of its kind in the world, named LabOceano, which is still active to this day. It was conceived with a focus on developing technologies related to the oil & gas offshore industry, such as Floating Production Storage and Offload (FPSO) platforms and submersed equipment in deep waters. This laboratory, along with other laboratories that came to PTEC-UFRJ's land in the future, are not properties of the Technology Park (meaning they belong to the university and are controlled by other entities of UFRJ, not by PTEC-UFRJ itself). Nevertheless, they are valuable resources to the park and makeup an important aspect of university-industry interactions that are expected to arise inside a Technology Park.

During its early years (2003-2010), PTEC-UFRJ's management team and operational staff were housed inside COPPE's Business Incubator. Up to early 2009, as there were no resident companies generating income to the park, the business incubator and COPPETEC provided financial support to the park's then small personnel. As noted by one interviewee, this was cohesive, provided that during this time the park was only housing laboratories (owned by the university), and Maurício Guedes was managing both projects.

When the park was conceived, as stated in its first Master Plan approved in 1997, it was from the start oriented towards being multi-sectorial, including fields such as oil & gas, Information and Communication Technology (ICT), and others. However, according to one interviewee, during its early stages (2003-2009), efforts were focused

on attracting ICT companies to the park. This strategy did not produce the expected results, one of the contributing factors was the geographical location of the park, ICT companies would prefer to be located downtown and physically close to their clients, another contributing factor was the availability of high-end internet infrastructure in Rio de Janeiro's city centre region. Regardless of the outcomes, even though no resident companies entered the park between 2003 and 2009, active prospection was being performed during this time.

During the late 2000s, Petrobras announced the discovery of light oil in the pre-salt layer, and this kicked started a chain of events that would heavily impact the course of PTEC-UFRJ's history. Petrobras undertook heavy R&D investments in order to develop technology for exploring these new reserves. One of the early steps in this direction was the expansion of CENPES, its R&D centre located inside UFRJ's campus. According to one interviewee, around 2007/2008 Petrobras entered a partnership with the COPPETEC foundation in order to erect three buildings inside PTEC-UFRJ's land, the buildings would be used to temporarily house professionals involved in the expansion of CENPES. Under this agreement, Petrobras would fully finance the construction of the new buildings, utilize them for a specific amount of time, and then gradually transfer the buildings back to COPPETEC permanently.

Matching its early strategy to attract ICT companies, still standing during this time, PTEC-UFRJ named one of the three new buildings "CETIC", standing for Excellence Centre in Information and Communication Technology, to be divided into 20 to 25 sqm office spaces for SMEs wanting to enter the park (after space being freed-up by Petrobras). The second building was named "MP", standing for Prototyping Module, to also be subdivided into several spaces with double height for more industrial project development. The third building would later be used to house the park's management facilities and its auditoriums for hosting events.

Up until early 2009, the only companies inside PTEC-UFRJ's land were start-ups at the business incubator in addition to Superpesa. Petrobras had started the gradual process of vacating the buildings utilized during the expansion of CENPES during that year. In this occasion, one building (MP) had a minor part of its area freed-up and returned to PTEC-UFRJ (via COPPETEC). PTEC-UFRJ's first resident company officially entered the park in 2009 to occupy this newly available spot inside MP. Named PAM-MEMBRANAS, the first resident was a spin-off of a COPPE

laboratory, which grew inside COPPE's Business Incubator for four years, later moving in as a resident of the TP in March 2009. This company remains active and located at the TP as of 2020. Later on, between 2010 and 2011, Petrobras continually freed-up more space in the buildings utilized during the expansion of CENPES. At this moment, PTEC-UFRJ began a movement to launch public offerings for SMEs to enter the park at the newly available spaces in the shared buildings.

Also due to the pre-salt rush, Petrobras invited suppliers and partners to work in the development of technologies, exploration, and production of the newly found reserves in the pre-salt layer. According to our interviewees, PTEC-UFRJ was an easy choice for locating new R&D centres of these companies: the pre-salt reserves were mostly in the Rio de Janeiro and São Paulo region; Petrobras has its headquarters in the city of Rio de Janeiro; and its R&D centre is located inside UFRJ's campus; PTEC-UFRJ was ready to receive companies in terms of infrastructure and governance; and the university has a long-time expertise in the oil & gas sector and a very good reputation for its graduate school of engineering (COPPE). Because of this, PTEC-UFRJ started to receive large oil & gas multi-nationals as residents very quickly.

In 2010 PTEC-UFRJ received its first large sized company, Schlumberger, a multinational company founded in France and headquartered in the USA, specialized in upstream oil & gas services. The company does not perform retail oil sales or refinery itself, they provide technology for finding reserves, drilling, and operating wells. According to the company's website: "we invent, design, engineer, and apply technology to help our customers find and produce oil and gas safely and efficiently". The research centre in Brazil would be focused on geology, relating to the specificities of the pre-salt reserves, and software development for the oil industry. 48 million USD have reportedly been invested in the construction of the research centre. On the same year, Schlumberger had also inaugurated an operational base for the Campos Basin in the city of Macaé - RJ, reportedly investing 65 million USD on it. The research centre is linked to agreements made between Petrobras and Schlumberger for the co-development of technologies to be used in exploring the pre-salt reserves, four deals had already been closed in 2009, while possibilities for other projects would be analysed further (FAPESP, 2009, p. 26).

In August 2011 Halliburton, a multinational oilfield service provider, began the construction of its research centre inside PTEC-UFRJ, which was inaugurated in June

2013. Halliburton had a history of partnerships with Petrobras, for instance, in the building of two FPSO platforms in the Campos Basin, which should have been delivered in 2003 and 2004, but both were delivered over one year later, an event which prompted conflict between the two companies. In 2007, Petrobras had also granted Halliburton a contract to provide exploration and development testing services. In 2017, a new contract was granted for Halliburton to provide technological solutions focused on reducing the costs in building wells, monitoring the reserves, and raising productivity of wells (NEITEC/UFRJ, 2017). In 2019, a new contract was granted for drilling services to be performed in the Libra oilfield.

In 2011 Baker Hughes, another oil field service provider, inaugurated its research centre inside PTEC-UFRJ, 50 million USD have been invested in the centre (Petronotícias, 2011). This was part of a deal made in 2009 between Petrobras and Baker Hughes to jointly develop technologies aiming at reducing the costs of pre-salt reserves assessment and production. In 2016 General Electric Oil & Gas (GE O&G) started the process of acquiring Baker Hughes, which was completed in July 2017, creating the world's only full stream oil & gas company. In 2016 the new Baker Hughes research centre at PTEC-UFRJ was divested, having some of its physical assets being relocated to other Baker Hughes facilities or sold (ABIMAQ, 2016).

GE itself is a company that entered PTEC-UFRJ for a small period of time. The Municipal Law No. 5360 (GE Law) of January 2012 was passed by Rio de Janeiro's mayor with the very specific aim to allow General Electric (GE) to build its research centre in a portion of the Fundão Island, which was military property back then and was acquired by the local government. The area, known as Bom Jesus Island, had been protected by a federal law since 1945 as a memoir of Brazilian soldiers who fought in the Paraguay War (1864-1870). The area spans around 240 thousand square meters, from which GE was granted the use of about 47 thousand square meters, expiring in 50 years (having the possibility to extend the concession by another 50 years). Before the construction of the new R&D centre, GE's was temporarily located inside PTEC-UFRJ, starting in 2011. The R&D centre located at Bom Jesus Island was officially inaugurated in November 2014, when GE left PTEC-UFRJ and moved to the new Bom Jesus Island facility. The company planned to invest one billion USD in the centre until 2020. According to PTEC-UFRJ's website, GE's research centre covers a broad range of areas, including oil & gas, engineering & advanced automation, and

civil aviation. A unit of GE's corporate university, Crotonville, was also planned to operate inside the centre, being the sixth unit worldwide (ANPEI, 2016).

GE's decision to be located at the Bom Jesus Island was not so straightforward. In the letter written by the then mayor of Rio de Janeiro, Eduardo Paes, to the legislative chamber as justification for the GE Law, it was stated that many municipal and state governments in Brazil were competing for GE's new research centre through offering fiscal and land incentives. GE signalled interest to build the new centre in the city of Rio de Janeiro, but imposed two demands: (1) fiscal incentives, and (2) the rights to use a 50 thousand square meters land area. Still according to the letter, "the municipality verified the existence of a estate with approximately 50,000 sqm next to the Bom Jesus base" (Rio de Janeiro, 2011), and provisions for the demanded fiscal incentives were already being taken care in another legislative project, namely reduction of the Tax Over Services of Any Nature (ISS) - paid to the municipal government. This fiscal incentive was officialised in the Municipal Law No. 5344 of December 2011, which fixed ISS taxation at 2% very specifically for R&D and project management services, in scientific and technological areas, for companies physically located at the Bom Jesus Island and the original land area of PTEC-UFRJ.

GE's land area was purchased from the military by the city of Rio de Janeiro in order to complete the transaction. The remaining area of Bom Jesus Island was purchased by the state of Rio de Janeiro, excluding portions containing historical buildings. Part of the land purchased by the state of Rio de Janeiro was set to be preserved, while the remaining portion was meant to be occupied by research centres from other companies. Companies located at the Bom Jesus Island were not directly incorporated under the management structure of the PTEC-UFRJ, although physical proximity did result in eventual collaborations.

The coming of GE to the Bom Jesus Island was not the result of direct negotiations between the company and the park. GE had decided for internal reasons that a new facility was going to be constructed in Brazil, according to one interviewee, the pre-salt discoveries were one of the reasons for this decision. Upon this announcement, several cities across the country offered benefits in order to attract the company, Rio de Janeiro being one of those. The city had a municipal government agency named Rio Negócios, responsible for prospecting and attracting businesses to the city, this agency, along with other government actors, worked in the negotiations

with GE to bring its new facility to the city of Rio de Janeiro. Offering land for the construction of the new facility was a critical point in this negotiation, and GE decided to take Rio de Janeiro's offer. The size of land offered in this negotiation was too big to fit into PTEC-UFRJ's land blocks, as such, the park's main area was not considered to house GE's new facility.

L'Oréal was the second company to be established in the Bom Jesus Island, for which the negotiations started in 2011. L'Oréal announced in September 2012 the official planning for the construction of the centre, which was set to start operations in 2014, though the inauguration only happened in October 2017. At the time, L'Oréal already had three facilities in Brazil, one factory in the city of São Paulo, another one in the city of Rio de Janeiro, and an office building, the Brazilian headquarters, also in the city of Rio de Janeiro. Research activities were already being carried out in these facilities (excluding São Paulo) prior to the new R&D centre, with the company reportedly employing 50 researchers, which would be relocated to the new R&D facilities after its inauguration (Nogueira, 2011). This would be L'Oréal's sixth research centre in the world and the only one in Latin America, justified by the fact that Brazil constituted the third largest market in the world for cosmetic products, personal hygiene, and perfumery (Almeida, 2012). The research centre would have the objective to customize global technologies and products to better fit the expectations of Brazilian customers, with a high emphasis on hair cosmetics, but also performing activities related to skin products and perfumery (Exame, 2012).

According to one interviewee, L'Oréal did not consider building its research centre inside PTEC-UFRJ's main land area for two reasons: (a) the size of the centre was too big to fit into available land blocks of the park; and (b) the new facility would be designed to be energy friendly in terms of, among other things, maximizing natural wind ventilation and sun light, and the land at the Bom Jesus Island offered the necessary conditions for this to be possible. PTEC-UFRJ was reportedly involved in attracting L'Oréal to the Bom Jesus Island, although details of this participation have not been collected during our interviews.

While both GE and L'Oréal are not associated to PTEC-UFRJ under formal contractual relationships, proximity with the university and the park has sparked some successful and some attempted interactions. With the strongest relations being with L'Oréal, this company has engaged with projects conducted by the park for

articulations with the university in a number of occasions, and interactions initiate from both sides.

In 2011 the park's personnel finally moved into its dedicated office building. This was one of the three buildings constructed under the Petrobras agreement, and was transferred back to COPPETEC in 2011. As mentioned before, the park's personnel were previously working inside the business incubator, with different areas allocated inside different spaces in the building, not physically consolidated. When Petrobras completely freed up the building, it was reorganized into the auditoriums for holding events and the management offices.

Still in 2011, the park began working on a project named "Innovation Tower", which was conceived with two functions in mind: (a) to work as a new shared building for new resident companies; and (b) to provide convenience services in the park, such as a barber shop, cafeteria, restaurants, newsstand, convenience stores, and a hotel, this would tackle the issue of the park being physically distant from such types of services (there is only one restaurant inside the park). Examples provided by one interviewee related to visiting researchers coming to work on projects in the university, who would not need to leave the campus during their trips when the Innovation Tower was ready. In March 2011, a partnership was made between Sebrae and the park in order to complete a viability research. However, due to the subsequent crisis in the oil & gas industry (discussed over the next subsections), and uncertainty regarding the mechanisms for acquiring investment funds, this project was deprioritized and did not evolve past the initial viability study.

In 2012, PTEC-UFRJ's team played an active role in trying to solve one of the main complaints received by resident companies: that of security problems immediately outside the park's area. According to one interviewee, security inside the park itself was kept at a high level, and resident companies recognized this, but the immediate surroundings of the park (the rest of the university campus itself and the main road giving access to the campus) was suffering from security issues. Of course, this is systemic to the Rio de Janeiro city as a whole, and security attributions in these areas lie outside the park's control. However, during this time there was a specific problem related to a group of criminals performing short-term kidnappings inside the university campus. On one occasion, an executive of a resident company was kidnapped by this group. The park's management team took an active role in trying to

tackle this problem, Maurício Guedes (then General Director) and Ismael Barberan (the Director of Operations), met with Rio de Janeiro's public security secretary (Marta Rocha) to request that actions should be taken regarding this specific issue. The efforts were successful: Rocha arranged for a public security team to work on finding this group, and they were finally arrested in the nearby city of Petropolis. Unfortunately, some four years after the arrest, the group was released, and the same events began to happen again. Nevertheless, as said, this is a governmental issue outside PTEC-UFRJ's control, but this specific event provides an example of the park actively acting upon its environment.

From 2012 to 2013, according to one interviewee, the park began working on trying to map the competencies available within the university, in order to facilitate the process of interactions between resident companies and researchers at the university. Around the same time, the university itself had some initiatives to develop such a map (i.e., listing laboratories, researchers, and what type of technology and expertise they have developed), the graduate school of engineering (COPPE) had an initiative named "COPPE Ideia", producing booklets per area of expertise, such as energy, mobility, etc. Another effort was initiated under the university's dean office, named CRIAR (Coordination of Institutional Relations and Articulations to Society), which would also work on mapping competencies of the entire university. Such efforts are valuable to the park since UFRJ is a large university with a very diverse set of competencies, spread across multiple campuses, and a number of laboratories in the thousands, therefore, such a mapping would aid in successfully articulating the productive sector with the university.

However, both COPPE Ideia and CRIAR have eventually come to a halt. PTEC-UFRJ is still working on its own efforts to produce such a mapping, for instance, via partnerships with researchers in the university to produce a software-based search engine for the competencies available in the university. Meanwhile, UFRJ's Innovation Agency is working on a separate effort to map competencies, named the "Inovas". The Innovation Agency performs the role of a TTO (or NIT, as per the Brazilian nomenclature) inside UFRJ, and the Inovas are planned to be extensions of the agency inside different departments of the university. As of May 2020, the Inovas were still at the beginning of a pilot project.

During this period, PTEC-UFRJ created a new functional area named “Institutional Development”. The main functional areas of the park, previously, were Corporate Articulations and Operations. The first of these concerned with all of the core activities of the park that have to do with university-industry interactions and prospection, and the second one concerned with real estate services and facilities maintenance. The Institutional Development area was created to take some of the responsibilities which were previously assembled altogether with the main Articulations area: (1) strategic planning of the park; and (2) development of projects outside the scope of technology and R&D&I. These concern themes of culture, arts, social and environmental sustainability, and other projects to benefit the university and the local community in varied ways (for example, prizes for best research developed by UFRJ students in specific themes, funding scholarships, etc). Regarding the last item, PTEC-UFRJ was not only concerned with the matter of social responsibility, but also with generating engagement from the academic and local community with the park, to turn the park into a “humanized” place, “a place where people would enjoy staying at”, as put by one interviewee.

In March 2013, the BG Group - a multinational headquartered in the UK - announced the building of a research center at PTEC-UFRJ, which was planned to be completed by 2016. BG’s main business revolved around exploring and extracting gas to produce Liquefied Natural Gas (LNG), which is easier and safer to store and transport, selling it downstream. At the event where the new center was announced, the then director of PTEC-UFRJ, Mauricio Guedes, acknowledge that “the oil and gas sector is one of the biggest strengths of the Technology Park, and BG’s presence will contribute manifold for the research and development projects” (COPPE/UFRJ, 2013). At the time, BG Group was part of the consortium of companies that owned the rights to the Lula oilfield, holding 25% of it (65% belonging to Petrobras, effective operator of the oilfield, and 10% to Galp Energia, a Portuguese company). BG Group was also Petrobras’ partner in other oilfields besides Lula. In April 2015, Royal Dutch Shell announced an agreement to acquire BG Group, the operation was completed on February 2016, for 52 billion USD, creating the world’s biggest LNG trader (Bousso, 2016). Shell was already taking part in pre-salt oil production, being one of the companies integrating the winner consortium for the first round of oilfield concessions under the new sharing framework - with a 20% stake of it -, for the Libra oilfield, where

41.65% of extracted oil should be given up to the Federal Government. Since BG Group's acquisition by Shell, the new research centre planned to be inaugurated at PTEC-UFRJ has been continuously postponed (ABIMAQ, 2016), according to one interviewee, BG's coming to the park was completely shut down.

Other large companies jointed PTEC-UFRJ to developed oil & gas related research and technology, between 2011 and 2014: Siemens, FMC (Later merged with Technip), EMC² (Later acquired by Dell), Tenaris, and Vallourec.

In 2013, only three years after receiving its first large companies and four years after its first resident, PTEC-UFRJ was already widely recognized as one of the most prominent Technology Parks in the country. Symbolizing the success achieved by PTEC-UFRJ and the wide recognition it received, not only in Brazil but also internationally, in 2013, the then vice-president of the United States, Joe Biden, was to hold a meeting in the city of Rio de Janeiro with representatives of the private sector. On that occasion, PTEC-UFRJ was chosen to host the event, because the UFRJ's Technology Park was deemed a symbol of Science & Technology, which would be a central theme of the event.

At the beginning of 2014, a judicial conflict arose between UFRJ and Superpesa. The agreement between the two organizations had been renewed last on the 31st of August 2009, for four years, having then expired in September 2013. According to André Cardoso, director of UFRJ's Music School at the time, "in 2013 the direction of the technology park informed that the contract would not be maintained, and the argument was simply that there is no synergy between the park and the company" (Adufrj-SSind, 2014, p. 3). According to the same report, Carlos Antônio Levi, UFRJ's dean at the time, commented that Superpesa was "occupying a large portion of the park, inflicting pecuniary losses to the university". Superpesa refused to leave the area, which led the university to file a lawsuit against the company at the beginning of 2014. Shortly after, Superpesa became insolvent and entered judicial reorganization. In September 2014, the company notified the Music School that they should leave the building, and legally required that UFRJ should not be allowed to withdraw money, which had been deposited for rent by Superpesa. As informed by one interviewee, an agreement was reached between the park and Superpesa, under which the company would gradually reduce the land area that it occupies, and should

participate in the financial contributions for the park's services under conditions elaborated specific to their case.

Still in 2014, the park began the structuring of a formal Communications area. A professional journalist with a degree in communications and experience in corporate publicity was hired to head this new function, upon her arrival, there were only three interns working on this activity. The new area was named Internal and External Communications, and the area was subdivided into topics such as events, visits, and social media, besides articulating with standard press and news outlets to expand visibility of both the park's brand and innovations achieved by its resident companies. Another focal group was internal to the university - professors and students in general. This internal group proved challenging, as many people did not understand the purpose of the park and the reason for companies to be located inside a public university campus, also, the existence of a Technology Park and companies inside public universities was, and still is, a subject that can be controversial among members of the academia in Brazil. Therefore, the Communications area had a mission in promoting the understanding and acceptance of university-industry interactions as an important tool for innovation, and the presence of companies as a source of new opportunities for both students and professors. The Communications area also provided its services to resident companies of the business incubator. Although the park and the incubator were, and still are, formally distinct entities possessing their own governance body, the closeness between the two rendered a good deal of cooperation between them, providing communication services to the incubator and their residents is one of the examples of such closeness between PTEC-UFRJ and COPPE's incubator. In summary, the Internal and External Communications team was responsible for (1) promoting the park via traditional media such as newspapers and tv, and through social media and other online outlets; (2) promoting innovation and other R&D related success histories from resident companies, both SMEs and large companies (especially relevant for SMEs and startups, since they could commonly lack internal teams dedicated to communications); and (3) promoting the park inside UFRJ itself.

In August 2014, the Brazilian-Belgium beverage company AmBev announced the construction of a research centre at the park, on a 180 million BRL investment. The centre was set to focus on developing new beers, recipes, and packaging. Although

originally announced to be constructed at the Bom Jesus Island, the research centre was built inside the main area of PTEC-UFRJ, and was inaugurated in August 2018. When AmBev decided to build a new R&D facility, Rio de Janeiro's state government directed the company to the Bom Jesus Island, next to GE and L'Oréal, where land that was planned to host companies was still available. It happened that a visit to the area was set up so that AmBev representatives could get to know the location in person, in this occasion, personnel from PTEC-UFRJ were to receive these AmBev representatives to show them around the Bom Jesus Island. During this visit, Denise Medina, the park's director of Corporate Articulations at the time, invited them to visit the Technology Park before going into the Bom Jesus Island. It was then that these AmBev representatives became aware that there was still land available at PTEC-UFRJ for new companies to enter, and reportedly manifested interest in building their new facility into the Technology Park (instead of the Bom Jesus Island) shortly after.

In 2015, the park launched its post-incubation program (Salomão, 2019) to provide a more intensive support for companies coming in as residents just after graduating from a business incubator. The program was designed to offer two types of services, general and personalized. General services include events for networking, spreading information, and discussions, specific services were based on frequent meetings with the companies to track their specific needs and develop action plans for each individually, the frequency could be as high as weekly meetings. Salomão (2019) identified a trade-off here regarding the perception by post-incubated companies that specific services rendered the most value, but, at the same time, lacked the ease to scale as fast as the general services. In addition to the services provided under the post-incubation program, companies coming from incubators had a facilitated selection process. To date, most companies, which entered the park coming from an incubator, stem from COPPE's business incubator, and this is viewed, by multiple interviewees, as the most natural pathway for those companies to follow.

On the 16th of November 2015, José Carlos Pinto became the new director of PTEC-UFRJ. The previous director, Mauricio Guedes, retired from the university. He had been in charge since the inception of the Technology Park, in 1997. Mauricio Guedes had also concomitantly remained as coordinator of COPPE's business incubator until retiring from the university. Guedes was the vice-president of the International Association of Technology Parks (IASP) from 2008 to 2010. In May 2010,

he became the president of IASP, remaining in charge until February 2014. He had also been the president of the Brazilian Association of Entities for Promoting Innovative Entrepreneurship (Anprotec). José Carlos Pinto's background was as a professor in chemical engineering at COPPE, being a member of the Brazilian Science Academy and the National Engineering Academy. He had also worked as executive director for the COPPETED foundation - entity responsible for managing contracts between the university and private companies, and the park's financial resources - from 2011 to 2015.

2015 was at the height of the global oil & gas crisis, accentuated by a national economic and political crisis, as a result, PTEC-UFRJ felt some pressure from oil & gas resident companies who wished to reduce their residency costs:

[...] there was a crisis, the oil crisis, the pre-salt crisis, when everyone was short on money. And, logically, there was a strong pressure from companies, that [said]: "oh, we are paying this money but we want to see where it is being used, how it is being used" [...] (Interviewee B)

Before the transition of General Directors, Maurício Guedes responded to this pressure by being completely transparent with resident companies regarding the park's costs. The closing of 2015 marked the first time PTEC-UFRJ reached a financial breakeven point, when revenues (after discounting the portion that is dedicated to UFRJ instead of utilized by the park) surpassed its operational costs.

[...] it was the first time the park reached breakeven. We reached a sufficient revenue [level] to pay for the operational costs. It was extraordinary, no park in Brazil was in such a condition, at the time, everyone relied on subventions. And [PTEC-UFRJ] has an attitude towards UFRJ which is [...] generous. The park does not keep one penny from the land rents, 100% of the land rents go to the Dean's Office, go to UFRJ. And other parks, in other states, even when renting land and keeping the rental income, could not support themselves [...] (Interviewee N)

One of the characteristics of José Pinto's tenure as Director of PTEC-UFRJ was an orientation to reduce costs where it was possible without compromising the quality of services. As a result, from 2015 onwards, PTEC-UFRJ has continued to maintain costs below revenue consistently, not only that, but an upwards trend in financial performance has been observed between 2015 and 2020.

In 2016, the acquisition of EMC² by Dell was an interesting event: the acquisition was performed after EMC²'s research centre was already built and operating inside PTEC-UFRJ, however, Dell already possessed one research centre inside another Brazilian Technology Park, Tecnopuc (Porto Alegre - RS). According to one

interviewee, the company decided to keep only one of the centres in operation, and the centre located at PTEC-UFRJ was ultimately chosen to keep on carrying these activities. Nevertheless, still according to the same interviewee, the decision was 100% internal to the company and there was no active competition between the parks to influence this decision.

In November 2016, a new facility for the Farmanguinhos pharmaceutical technology institute was announced. Farmanguinhos is a branch of the Oswaldo Cruz Foundation (Fiocruz), a Brazilian government research and development institute in biological sciences. The new Farmanguinhos facility was conceived to work on developing technologies to allow national production of active ingredients for drugs. Justified by the fact that Brazil heavily relies on importing the vast majority of active ingredients for drug production, this would be a first step into safeguarding the country against possible instabilities in the international trade and supply. According to PTEC-UFRJ's website, Farmanguinhos research facility would set "priority over [the drugs] for treating old illnesses afflicting the Brazilian population, such as malaria, schistosomiasis, leishmaniosis, among other neglected illnesses". Construction was planned to begin in 2018, and operations were planned to start in 2019, however, as of February 2020, operations have not begun.

In April 2016, PTEC-UFRJ opened its co-working space. Divided in 20 modules, each module has two private workstations. A meeting room and common living spaces are available, along with other shared infrastructure and services provided by the TP, such as telephone lines, reception, security, WiFi, and cleaning, and also business capacitation and advisory services. Entrepreneurs apply through a public selection process; the ones, which are granted participation, are allowed to use the space for one year, having the possibility to extend it for a second year.

According UFRJ's Innovation Agency's website, in December 2016, a "Soft-landing" program was established between PTEC-UFRJ, Tecnopuc (Porto Alegre - RS), and Porto Digital (Recife - PE). A Soft-landing is an exchange program for companies, allowing tenants from each TP to visit and work inside other TPs for a period. Originally, five spots were made available in each co-working space of the partner TPs to allocate visiting firms. According to the PTEC-UFRJ director, at the time, José Carlos Pinto, the program was the first of its kind among Brazilian TPs, and their aim was to expand the number of partners in the future.

Shortly after, a similar partnership has been announced between PTEC-UFRJ and the Chinese Tsinghua University Technology Park (TusPark). In this partnership, small and medium companies from both parks could spend up to thirty days in the partner's facilities, receiving attention from the TP's staff in activities such as "prospection, networking, learning about fiscal matters, etc.", the companies would have the possibility of applying to be an official tenant in the park. An effort to easy and encourage the internationalization of tenant companies. Tsinghua University is headquartered in Beijing, having campuses spread in other Chinese cities. The university is frequently listed among the world's top universities by Times Higher Education, for instance, in 2019 Tsinghua was ranked the number one university in Asia, and 23rd in the world.

In 2017, the park launched a pre-incubation program on a partnership with Telefonica, selected participants received slots in the park's co-working space. This was based on Wayra's (Telefonica's business incubator) pre-existing model of business acceleration. Telefonica made efforts to replicate that model in multiple locations across Brazil, and PTEC-UFRJ was chosen as its partner for the city of Rio de Janeiro. Telefonica provided the park with the guidelines for the model, and the park's personnel were fully responsible for carrying it out. Every four months, Telefonica sent out a team to participate in the evaluation of CrowdRio participants, deciding which ones would remain or be dropped based on targets set to be achieved over those four months. The objective was for CrowdRio to serve as a filter for companies to ultimately join Telefonica's business incubator, Wayra. However, no company in Rio de Janeiro ended up being selected to join Wayra, and CrowdRio was shut down after two years.

In 2017 the National Service for Industrial Learning (SENAI), announced plans to move the Biosynthetics unit of its Technology Centre for Chemical and Textile Industries (CETIQT) to PTEC-UFRJ. CETIQT is an educational institution possessing laboratories for research and development activities and professional training to the textile industry. Its Biosynthetics unit was launched in 2016. Operations in the new location were planned to begin in March 2019.

PTEC-UFRJ, in its 2017 sustainability report, highlighted that the TP was undertaking efforts to diversify the portfolio of tenant companies, gradually moving away from a high concentration in the oil & gas sector:

“The focus of the Park in 2018 as well as for the coming years will be all about working the pillar of diversity. We believe that the arrival of the Senai Institute for Innovation, as well as the acceleration project of the national reference centre for pharm-chemistry of the Technology Institute in Pharmaceuticals of Farmanguinhos/Fiocruz, correspond to the beginning of a process of acceleration of actions directed at that motto.” (p. 20)

In February 1st, 2019, UFRJ's Biotechnology Pole entered a transition period to be incorporated and managed under the TP's structure. The Biotechnology pole was established inside campus in 1988 with the aim to promote entrepreneurship in the fields of biotechnology and biodiversity through cooperation between the academia and private enterprises, specifically for companies wishing to engage in R&D activities (Aguiar, 2006, p. 2). In reality, BioRio was a Technology Park in itself, having been listed as such by MCTIC (CDT/UNB, 2019, p. 26). The Biotechnology Pole has its own business incubator, shared laboratories, and business services, such as consultancy, training, planning, etc, along with shared basic services such as cleaning, security, reception, telephones, etc. As of 2020, there are 30 tenant firms. The Biotechnology Pole was managed through the Bio-Rio Foundation, as of 2018, Bio-Rio's concession expired, which prompted its transferring to be managed under PTEC-UFRJ. The transfer period was set to be an entire year, during which time bureaucracies had to be sorted out, such as converting the types and amounts of pecuniary contributions made by tenants, to match the system utilized by PTEC-UFRJ. In addition, the Innovation Law had mandated some rules regarding the entrance of companies inside a Technology Park, such as equality of opportunities, thus, tenants of the Biotechnology Pole would have to send in their legal documents and proposals to be accepted by PTEC-UFRJ, in order to constitute an official, and public, selection process. However, difficulties arose during this process due to changes in the General Attorney's Office of the university (representatives of the Federal Government). A new interpretation of the legal framework suggested that offerings cannot meet the criteria of the Innovation Law in case the companies were already located inside the park, for this reason, ex-BioRio resident companies would have to leave the physical facilities before being able to participate in a public offering to officially enter the park as residents.

In November 2019, Vicente Ferreira became the new director of PTEC-UFRJ, substituting José Carlos Pinto, which had been in charge since November 2015. Ferreira holds a M.Sc. in business and a PhD in Economy, being a professor at UFRJ's

COPPEAD Graduate School of Business since 1998, where he was also the dean from February 2014 to February 2018.

In late 2020, PTEC-UFRJ concluded the construction of the project (originally) named “Cubo”. Cubo was conceived in 2010, it was meant to be a shared space to promote networking, culture, and entertainment (PTEC-UFRJ, 2016a, p. 75). “Cubo will be one of the most important steps for the process of humanization and occupation of the Park. We hope that it stimulates the arrival of new people that do not usually visit the Park but that will find good reasons to stay here with us” (PTEC-UFRJ, 2018, p. 21). According to one interviewee, this project was conceived after Maurício Guedes returned from a trip to Germany from where he brought a Rubik’s Cube and left it at the park’s management building, where it has remained. One person who was working at the park during that time decided they had to build a new facility inspired by the Cube, the original project was for the building to have moving parks and changing colours. However, due to a subsequent structural crisis in the oil & gas sector (discussed over the next subsection), the project was trimmed down and lost these later features. It took 10 years to complete the project due to multiple delays with funding for the construction, granted by FINEP. Construction of the facility was close to being finished by mid-2020, but due to the pandemic that struck during the year, inauguration was delayed.

5.1 Cooperation projects and investments

Small- and Medium-sized Enterprises (SMEs) can enter PTEC-UFRJ in three types of facilities: (a) office building divided in individual modules, (b) a warehouse type building suited for prototyping work, also divided into modules which can be combined, and (c) the co-working space. Large companies get concessions for a specified land area that can be used for a fixed amount of time. In this case, they will be entirely responsible for building their physical infrastructure (fiscal incentives may apply). The companies get a 20-year concession to use the land, which can be extended for another 20 years upon the end of the first period, subject to acceptance by the responsible committees. All tenant firms pay monthly rent based on square meters occupied, plus an administrative fee for the services provided by the TP. All companies are contractually obligated to perform interactions with the university, on a minimum

annual stipend calculated over gross revenues. Currently, for companies occupying the shared buildings, this sits at 3% of revenues, minimum. For companies generating between 50 and 90 million BRL, the requirement is set at 1.5 million BRL annually. Large companies taking concessions for land area, which build their own structures, have a minimum requirement to spend 3 million BRL per year, over the first five years, on cooperation projects interacting with the university.

The first large companies to enter PTEC-UFRJ, Schlumberger, Baker Hughes, and FMC Technologies did not have any obligations to invest in cooperation projects set forth in their land concession contracts. However, interviewees suggested that both Schlumberger and FMC do engage in cooperation projects with some frequency, although with different profiles (Baker Hughes is not mentioned here since it was acquired by GE). General Electric, which technically moved out of the Technology Park in 2014 - where it operated temporarily from 2011 during the construction of their research centre in Bom Jesus Island -, and therefore is not contractually part of PTEC-UFRJ, has reportedly also kept on participating in cooperation projects occasionally (PTEC-UFRJ, 2016a, p. 36).

The prescribed types of cooperation with UFRJ are: (1) Internship programs for students; (2) contracting full research projects or joint research; (3) donations for a scholarship fund; (4) utilizing the university's labs or sharing their labs under the terms of the Innovation Law; (5) social and environmental sustainability projects subject to approval; (6) projects planned by students involving companies at the TP; (7) sponsoring academic and cultural events; (8) investing in the university's infrastructure; (9) donating equipment, software licenses, services, products, and general resources; (10) training and professional capacitation programs. Other types of interactions can be suggested and requested, which will be subject to approval.

According to the park's 2018 sustainability report, 486 cooperation projects had been contracted from 2010 to 2018. The accumulated value of these contracts established between tenant companies and the university was 229.7 million BRL, of which 4.8 million BRL was directed towards R&D projects in university-business interactions.

5.2 Organizational structure

The park's management structure is currently organized as follows: The Directing Committee - composed by key stakeholders of the park (e.g., the university's dean, representatives from Rio de Janeiro city and state governments, representatives from each university department, etc.) - that appoints the Executive Director of the park. Directly under executive management, there are seven departments, listed below with a brief description of its main attributions (as informed by the park's website):

- (1) Administration and Finance - "its main activities are planning and tracking financial matters, bids, contracts, procurement, patrimony, human resources, and managing documentation";
- (2) Architecture and Urbanism - "Responsible for elaborating and managing the park's architecture, urbanisms, and engineering projects. Also responsible for elaborating and approving, along with the Architecture Committee, the norms for land usage, and for analysing all of the architectural and landscaping projects of companies applying for a spot in the park";
- (3) Corporate Articulations - "Establishes direct and continuous channels to promote university-business cooperation. Mediates contact between companies and the university foundations (COPPETEC and FUJB). Holds events and meetings that seek to stimulate the relationship between the organizations residing in the park and other stakeholders. Prospects companies to be inserted in the innovation ecosystem of the park";
- (4) Communications - "Responsible for internal and external communications of the park and the business incubator. Coordinates the press and communications team in the following activities: developing internal communication tools, relationships to national and international media, actions and content for social media, institutional visits, and holding events";
- (5) Institutional Development - "Responsible for articulating the corporate governance system to the management model, focusing on the fields of strategic management, promoting the innovation ecosystem, and sustainability actions [...]. The department works as a project management office, [...] with

power to elaborate, execute, monitor, and assess partnerships and projects which promote institutional development”;

(6) Operations - “Responsible for the park’s entire infrastructure. The main activities encompass the following areas: maintenance of shared buildings, urban and estate conservation, landscaping, estate security, fire safety, and IT”;

(7) Legal Advising - “Works at the interface with resident companies, focusing on consulting, contract elaboration, agreements, reports and bidding notices, as well as legal analysis of research and development projects. Supports the executive director in legal matters related to innovation and governance”;

In 2015, after the departure of Mauricio Guedes, the Executive Director position was set to last a cycle of 4 years, the prerequisites to be a new director are: (1) to be a UFRJ public servant, (2) indicated by the Directing Committee, and (3) accepted by the university’s dean. This four-year tenure was prescribed since the original Master Plan for PTEC-UFRJ approved in 1997.

5.3 Sources of financing

PTEC-UFRJ generates money in five different ways: (1) Rent for land concessions, (2) rent for shared buildings concessions, (3) service fee for land concessions, (4) service fee for shared building concessions, and (5) government financing for specific projects. Sources one through four are charged from tenant companies based on the size of their facilities, which type of concession they got (differentiated for each shared building and land concessions), and revenue level.

Source number one is entirely directed to the university, and not directly used for the park’s operations. Figure 14 next shows the amount of money generated to the university from this source:

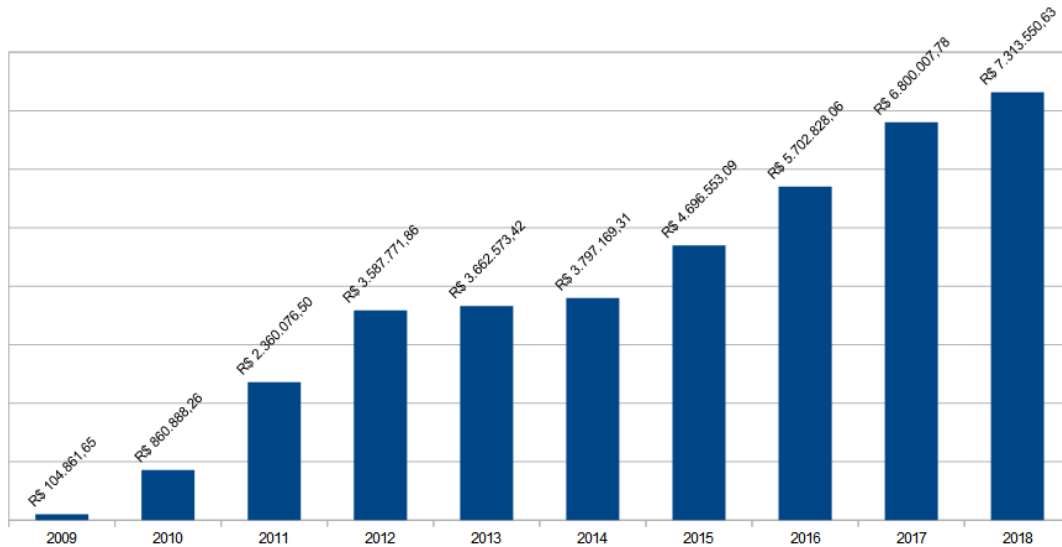


Figure 13 – PTEC-UFRJ's land concession revenue.

Source: PTEC-UFRJ (2018, p. 64)

Source number two is split in the following way: 1/3 goes to the park's operation, 1/3 goes to a scholarship fund (granted to UFRJ's students), and 1/3 goes to a "special projects" fund. This later fund is used to finance extension projects demanded by the university's professors, students, or public servants. Public offerings are made in order to collect project propositions, these projects are analysed by a committee, annually, and can be financed through the fund. Examples of projects financed by this fund are: The Gilberto Velho Thesis Award, which selects the best doctoral thesis in selected knowledge areas and wards money prizes for the authors; and the Academic Sports Representation of UFRJ, which coordinates and develops competitive sport events.

Sources three to five are entirely held for the park's operation (as mentioned before, COPPETEC is responsible for the financial management of these resources). Figure 22 below shows the evolution of financing sources kept for the park's operation, compared to operational costs. The data are from 2015 to 2018, since this is currently PTEC-UFRJ's only publicly available financial data:

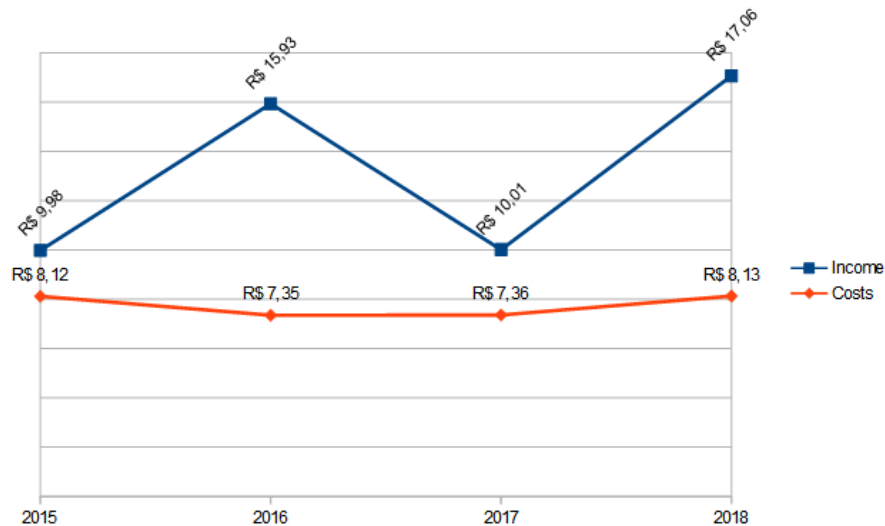


Figure 14 – Income x operational costs (in millions of BRL)

Source: PTEC-UFRJ (2016a, 2017, 2018, 2019)

Public financing during the years presented in the figure above were all granted through FINEP. Individual values for each year can be observed below:

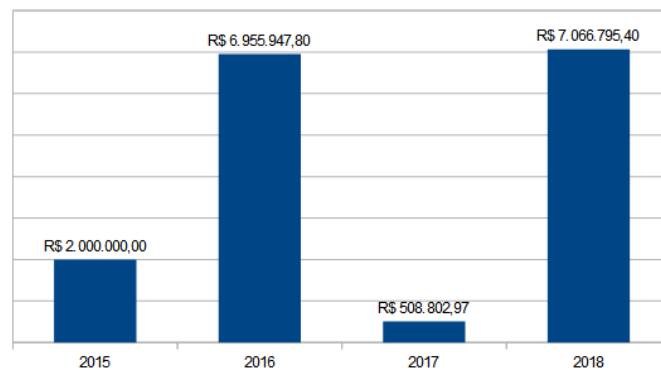


Figure 15 – Government financing (FINEP) by year

Source: PTEC-UFRJ (2016a, 2017, 2018, 2019)

As observed, FINEP grants heavily fluctuate on a year-to-year basis. In terms of percent participation, it represented 20%, 43.66%, 5.09%, and 41.42% of total operational financial resources, respectively for the years above in figure 23. PTEC-UFRJ informed through its sustainability reports that FINEP resources, in 2015, would be used for (1) kicking-off the first phase of construction of a new facility named “Cubo”, and (2) buying seedless for enriching the land’s biodiversity. In 2016 and 2018 the money would be used for (1) paying human resources, and (2) continuing the construction of Cubo.

5.4 Occupancy

According to the park's sustainability report for the year 2017 (PTEC-UFRJ, 2018) "in 2009 the first company was inaugurated at the park" (p. 25), referring to PAM Membranas. Thus, prior to 2009 the only companies physically located at the park were start-ups at COPPE's incubator. Though Superpesa had, and still has, their land concession inside the park since its inception.

From 2010 to 2017 a number of large companies established their research centres, as mentioned in section 4.3.2. Most companies followed through with the plans and remain in the park to this day. Exceptions include: BG Group - acquired by Shell before finishing its research centre, which has not been continued since -, Baker Hughes - acquired by GE, having its research centre divested -, BR Distribuidora, which had announced a facility in the park (further information cannot be found and it has been delisted from the park's reports). SMEs which joined during this period and didn't follow through with the plans, or left the park, include: Georadar - which announced an oil & gas research centre in 2012 but has been delisted from the park's reports in 2016 -, and ILOS - which left the park in 2015.

Throughout its entire life span, the majority of companies located at the park have been start-ups in the business incubator, large companies (mostly multinationals) come in second place, followed by SMEs. The figure below shows the composition of tenant companies from 2013 to 2018:

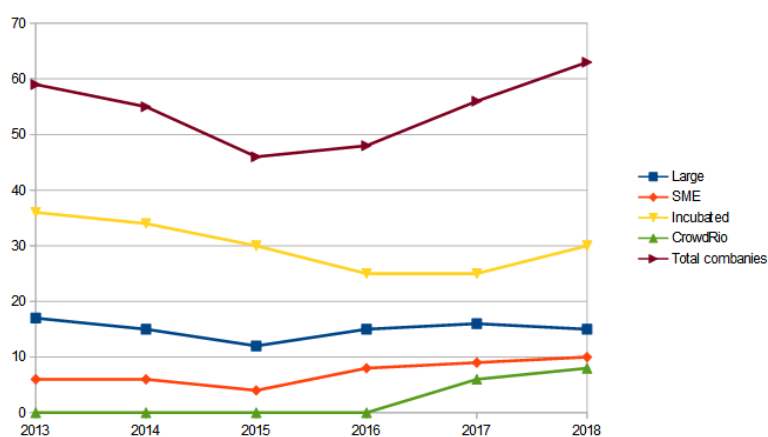


Figure 16 – Composition of tenant companies (2013-2018)
Source: PTEC-UFRJ (2016a, 2017, 2018, 2019)

Where “CrowdRio” refers to micro companies and/or individual people, which still haven’t constituted a formal company and have been selected to participate in the CrowdRio initiative conducted by PTEC-UFRJ in partnership to Telefónica and its business incubator (Wayra). CrowdRio offers “pre-acceleration” services to technology startups related to specific areas (IoT and Digital Technologies). Selected participants are granted access to spaces in one of the shared buildings and access to Telefónica’s global network of innovation services.

Companies graduating from COPPE’s Business Incubator are granted simplified selection criteria for entering PTEC-UFRJ in selection processes.

5.5 The 2014 oil crisis and its impacts on PTEC-UFRJ

As discussed before, the presence of Petrobras’ R&D centre (CENPES) inside UFRJ campus constituted an extremely critical factor for attracting new companies to the park. This was so especially after the discovery of new reserves in the pre-salt: Petrobras had declared interest in researching and developing technologies for pre-salt E&P in the country; and the government established a new Framework for pre-salt reserves (giving at least 30% of E&P concessions to Petrobras). PTEC-UFRJ’s “physical and relational proximity to CENPES, one could say represented and still represents an important attractiveness factor for the Technology Park” (PTEC-UFRJ, 2016b, p. 19). To provide an overall idea of R&D intensity relating to the pre-salt discoveries, Figure 25 below shows Petrobras’ R&D expenditures by year:

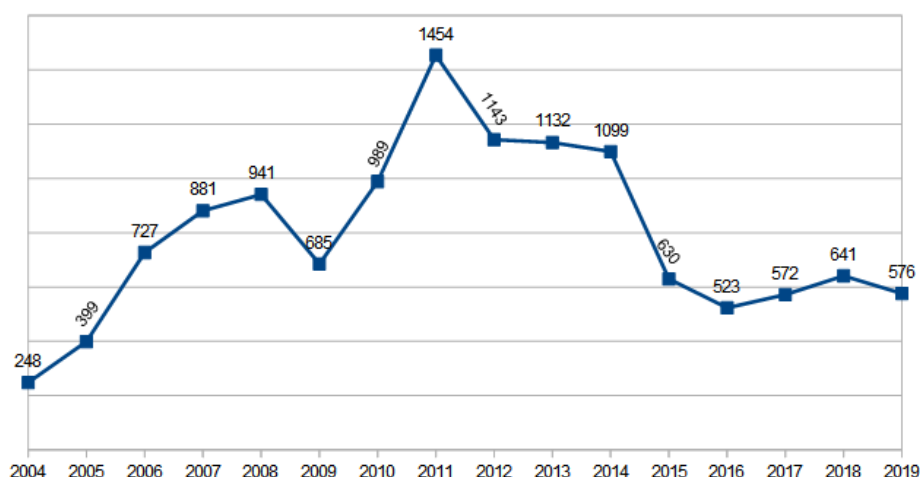


Figure 17 – Petrobras’ R&D expenditures by year (in millions of USD)

Source: Petrobras’ yearly Financial Statements

Where substantial increases can be observed from 2006 to 2008, during the early stages of pre-salt prospection, with a dip in 2009 after the global economic crisis, followed by the 2010-2014 period during which R&D activities related to pre-salt reached their peak.

A significant drop can be observed in 2015, reaching pre pre-salt levels, where it has remained. This drop can be timed to the early events of the “car-wash” operation in Brazil. Car-wash is the name given to a number of criminal investigations undertaken in Brazil starting in early 2014. Briefly:

“Launched in March 2014, the operation had initially focused on agents known as *doleiros* (black market money dealers), who used small businesses, such as petrol stations and car washes, to launder the profits of crime. But police soon realised they were on to something bigger when they discovered that the *doleiros* were working on behalf of an executive at Petrobras [...]. This link led prosecutors to uncover a vast and extraordinarily intricate web of corruption.” (Watts, 2017)

The operation quickly had many politicians and Petrobras’ executives implicated in multiple corruption schemes, including overpricing of acquisitions and other schemes. For instance: Nestor Cerveró - who had been the global director of Petrobras’ from 2003 to 2008, and financial director of BR Distribuidora (a subsidiary) from 2008 to 2014 - was arrested in early 2015, he had been dismissed from BR Distribuidora due to his exposure in the Car-Wash operation. In addition, Paulo Roberto Costa - who had been Petrobras’ Director of Supply from 2004 to 2012 - was arrested early on in 2014.

In January 2015, the then president of Petrobras, Graça Foster, announced that around 88.6 billion BRL of Petrobras’ assets had been indicated by auditors to potentially be overpriced, due to the latest information stemming from the criminal investigations regarding overpricing of assets in corruption schemes. The company proceeded to make this information public through a note. Graça Foster was removed from Petrobras’ presidency shortly after, being replaced by Aldemir Bendine, who stepped down from the presidency in May 2016, and was later arrested in early 2018 under the Car-Wash operation due to corruption schemes involving Petrobras (being released in early 2019 on a habeas-corpus). Bendine was replaced by Pedro Parente, which remained the company’s president until June 2018, when he stepped down. Ivan Monteiro followed as president for a short period, until Roberto Castello Branco was nominated in January 2019, remaining in charge up to this date.

The then director of PTEC-UFRJ, José Carlos Pinto, declared that “since the oil & gas sector is an intensive demander of technology, the reduction in Petrobras’ investments hits hard R&D&I [Research, Development and Innovation] activities” (Pinto, 2015).

Not only was Petrobras struggling with these corruption problems, but during this time oil prices in the international market had also dropped significantly. Figure 18 below shows the evolution of average crude oil prices per barrel from 1997 to 2020 (Benchmark: Europe Brent Spot Price):



Figure 18 – Crude oil prices per year, in USD/Barrel (Brent)
Source: Thomson Reuters

Where a sharp drop can be observed in 2009 following the global economic crisis, and then a new drop in 2014 and 2015, due to a number of international developments. This was almost perfectly timed with the Car-Wash operation. These disturbances resulted in very negative financial impacts to the company, which can be observed in the R&D investment levels presented before in figure 25.

Regarding this, José Carlos Pinto declared that “The decrease in international oil prices affects the investments of oil & gas operators and R&D&I activities of the sector, since pre-salt exploration costs can reach up to 50 USD per barrel” (Pinto, 2015). The ex-director declared in this interview a number of actions that should be undertaken in order to help the sector pull through the crisis, without wasting all of the advancements achieved up to that point.

The fallout of these events affected PTEC-UFRJ, given the high share of oil & gas tenant companies, and the close relationship between CENPES and the research centres and laboratories present at the park. To illustrate, between 2010 and 2019, fifteen new large companies became residents of the park (accounting for Baker

Hughes, BG Group, and BR Distribuidora, which didn't remain), from which 11 (73%) are/were involved in the oil & gas sector (accounting for GE and other companies whose centers are not solely focused on oil & gas). In 2015, 9 out of 9 large tenants in operational stage were directly related to oil & gas (excluding L'Oreal and Ambev, which were not operational yet), and 11 out of the remaining 34 companies (SMEs and incubated start-ups) were also directly related to the sector.

“[PTEC-UFRJ's] current Master Plan, elaborated in 2002, set petroleum and energy platforms, telecommunications and informatics, and environmental issues as priority areas for the development of the park's first ten years. The finding of oil & gas in the pre-salt fields imposed frontier technology challenges, attracting world-class research centres to Rio de Janeiro” (PTEC-UFRJ, 2016a, p. 73)

Due to the macroeconomic and political distress affecting the country's R&D investments and the overall innovation system, with clear effects being felt by PTEC-UFRJ, new strategic plans have been elaborated to foster a healthier and more stable future for the park.

5.6 Summary

Four main phases of the park could be identified: the first phase accounts for its ideation, planning, discussion and approval, plus the implementation of its basic physical features and legal instruments. This phase had its roots in the early 1990s, somewhat as seed planted out of the experiences with COPPE's business incubator, and ended upon the park's official inauguration in 2003.

The second phase encompassed the period from 2003 to 2009 upon the settling of Pam Membranas as the first company inside the park, and Petrobras' agreement with Schlumberger, which involved the building of a research centre inside the park. During this period, most companies physically located within the park were start-ups in COPPE's business incubator. During this period, a number of relevant policies had been settled in the legal environment, including the original Innovation Law (2004; 2005), the new framework for E&P activities in the newly found pre-salt oil fields, fiscal incentives to R&D&I activities, and more.

The third phase accounted for the fast growth of the park, mainly due to Petrobras' announcement of R&D investments for the exploration of the pre-salt layer and the partnerships that would arise there out. This brought the park to possess a

strong inclination for the oil & gas sector, attracting a number of large multinational firms to work within that sector due to its convenient location, availability of land area, links to a university with oil & gas expertise, etc. Quick growth in terms of resident companies and the park's infrastructure and teams happened between 2010 and 2014.

The fourth and last phase followed the downturn taken by the oil & gas sector, accentuated in Brazil due to political and corruption scandals revolving around Petrobras, plus macroeconomic factors pushing down international oil prices. During this stage, PTEC-UFRJ has quickly changed its strategy for diversification, and it did achieve some success in this pursuit, such as Senai CETIQT and AmBev.

6. Analysis

This section will perform the analysis of PTEC-UFRJ in light of Fleck's (2009) growth challenges and the archetypes of organizational success and failure. To briefly recapitulate, five basic challenges are described in this model: Enterprising, navigating into the complex environment, managing diversity, human resource provision, and managing complexity. Responses to these challenges provide insight into the central mechanisms of Organizational Integrity, Renewal through Growth, and Slack Generation.

Enterprising has to do with Penrose's (1959) description of the qualities of Entrepreneurial services. Ambition derives a drive for growth, versatility culminates into generating and pursuing ideas for novel undertakings, fund-raising ensures the capture of resources for expansion and maintenance, and judgement mediates the balance between taking necessary risks while avoiding exposure to unnecessary risks. Enterprising will culminate in establishing pairs of value-generation and value-capture mechanisms. **Navigating into the complex environment** has to do with scanning the environment for opportunities and treats, and applying active responses to take advantage of opportunities and mitigate threats. **Managing diversity** has to do with identifying heterogeneous and homogeneous resources and promoting bonding relations between and across them. **Human resources provision** has to do with anticipated provision of human resources for expansion movements, but also for maintaining the current operations. Succession mechanisms, retention, and training of human resources are also complementary areas of this challenge. **Managing complexity** is necessary to support the responses to all other challenges, as an organization grows, so does the complexity of its internal organization and of its environment, here, setting adequate support structures and information systems to allow for well informed decision making becomes crucial. The central mechanism of **Slack Generation**, when properly attended, ensures that the organization will have the necessary resources to adequately undertake growth. **Organizational Integrity** observes whether or not signs of fragmentation can be observed, for instance, via conflicts and political arenas, where adequate responses should ensure individuals do not treat the organization as disposable, i.e., this has to do with the process of classic institutionalism. **Renewal through growth** has to do with setting in motion the

mechanism of continuous growth, where the process of growth itself results in the availability of resources and services that can exert pressure to further growth.

6.1 Enterprising

Overall, PTEC-UFRJ has displayed strong enterprising qualities throughout its history. Its founder, Maurício Guedes, has been a notorious figure for the development of the Brazilian innovation scene even prior to the establishment of the park. Championing the proposal to build a Technology Park inside UFRJ in itself is a display of great Ambition. Actually, at that time, the concept of Technology Parks was not too widespread across the country. Besides that, there was a very small amount of similar initiatives, and there lacked any policies to support such initiatives, at the governmental levels and even inside UFRJ itself. In addition, Brazil has traditionally displayed low levels of engagement and output of technological innovation. Having gained support to kick-off such project, with unanimous approval by UFRJ's higher deliberating entity (Consuni) in 1997, in addition to government financing for building its urban infrastructure, Mauricio has provided Entrepreneurial services, such as ambition and fund-raising capabilities. The years from 2003-2009 saw the continuous engagement of Maurício, and other individuals such as Alfredo Laufer, in prospecting activities to attract companies to the park. Although no company entered the park in this period, the evidence that time and work was put into prospection activities (as opposed to a complete passive posture) shows that continued Entrepreneurial services were present during those years. The pre-salt rush brought many opportunities to the park, which were adequately harnessed by the park, enabling its growth.

Versatility has been displayed in many forms. The park did find room for diversifying its activities and services within the scope of university-industry interactions. Evidences include: diversifying sectors and sizes of resident companies; articulating interactions involving diverse areas of the university (including less obvious areas such as Arts); establishing and validating different forms of interactions (beyond exclusivity to R&D investments); helping resident companies to build their own plans for innovation; articulations with non-resident companies (both inside and outside UFRJ); offering business support services for SMEs; offering programs for individual entrepreneurs (such as CrowdRio, Startup Bio, and Entrepreneur Doctor); articulating

partnerships with other Technology Parks (nationally and abroad) for softlanding programs; establishing multiple ways in which interactions can flow (from resident companies, from external organizations, from researchers, and from students and employees of the university), as opposed to a passive posture of waiting for resident companies to request their support; and “university-park” interactions, where the park developed projects with some part of the university without necessarily having companies involved.

Fundraising skills have to be considered within the context of hybrid organizations in Brazil and the limitations that exist due to compliance with laws regulating the functioning of public entities. As such, PTEC-UFRJ has been observed to successfully work within the available tools it has at hand for raising funds outside the income generated by fees received from its residents. The park is able to work with public entities such as FINEP, CNPq, and other governmental entities to get money for specific purposes. Of course, its initial investment in infrastructure is one example; other examples include winning public competitions for investments from FINEP (applied to the construction of “Cubo”), and FAPERJ (for the Living Labs project). Another example includes participation in the Entrepreneur Doctor program, launched by FIRJAN, from which additional funds can be received depending on the number of researchers housed by the park.

Judgement can be assessed indirectly by some clues. Over the park’s history, no major negative event, originating from the park’s internal decisions, could be observed. In addition, the team has been engaged in collecting information from its environment in a variety of ways. Being active in associations such as Anprotec and IASP, establishing connections with other parks, surveying resident companies to track results, etc.

The following table provides a quick synthesis of the park’s Entrepreneurial qualities, with a general assessment and brief pieces of evidence of the park’s behaviour. Over this subsection, we will go into detailed description of these pieces of evidence.

Table 6 – PTEC-UFRJ's Entrepreneurial Services

Dimension	Organizational behaviour
Ambition	<p>Strong.</p> <p>Supporting innovation against the backdrop of a country that has historically not engaged and outputted much technological innovation, with an organizational type that was not common back when PTEC-UFRJ was conceived and built. The park has grown, expanded the scope of activities, engaged with a diverse set of actors, and continues to plan new venues of growth, while not deviating from their essential role as articulators of research institutions and enterprises for R&D&I;</p>
Versatility	<p>Strong</p> <p>Diversification of resident companies in terms of maturity: acquiring the physical infrastructure to support SMEs on shared spaces, and a coworking space for receiving nascent entrepreneurs; Offering business support services specific to SMEs and nascent entrepreneurs; Diversification of sectors past the pre-salt rush; Articulations with non-resident companies; Planning for digital transformation (associated non-resident companies); Articulating interactions not directly linked to technological R&D&I; Establishing different channels to kick-start interactions; Offering help for resident companies to plan interactions for innovation; Highly diversified portfolio of events.</p>
Fund-raising	<p>Considering what is possible within the strict regulations faced by the park, PTEC-UFRJ has had adequate success.</p> <p>The park was successful in harnessing funds from the government to make its construction viable; Being supported by COPPE's Incubator until the park received its own residents; Winning investment bids from public entities such as FINEP and FAPERJ; Joining income generating programs such as FAPERJ's Entrepreneurial Doctor; Harnessing opportunities from the pre-salt rush for the construction of buildings by Petrobras;</p>
Judgement	<p>Adequate</p> <p>No major negative event could be observed in its history and traced back to internal decisions of the park; The major risk observed was related to the concentration of oil & gas companies, due to the eventual crises in the sector. However, the pre-salt rush was the opportunity responsible for PTEC-UFRJ's initial growth. The park has not failed to observe the risks involved, never departing from their multi-sector strategy, and actively pursuing diversification.</p>

Source: created by the author

In terms of ambition, planning PTEC-UFRJ and its effective construction was an ambitious goal in itself. According to CDT/UnB (2019), In Brazil, there were only 10 Technology Parks (under planning, construction, or operation) in the year 2000, as the concept of Technology Parks was simply neither well known nor widespread in the country. In addition, the private sector in Brazil has historically not engaged in much R&D&I activities, with low rates of innovation being widely reported by surveys such

as PINTEC, and indicators such as GERD (% of GDP spent on R&D), number of personnel hired as researchers, and more. Making things even more challenging, “S&T [Science and Technology] institutions and organizations in Brazil lack[ed] the participation of private firms and linkages” (Bastos, 1995, p. 61). In general, multiple factors “contributed to a weak performance of the Brazilian innovation system during the 90s” (Villaschi, 2005, p.1). Moreover, Brazil’s first law towards innovation and university-industry interactions was passed only years after the park was conceived and built; Rio de Janeiro State’s innovation law followed a few years afterwards, and UFRJ’s internal innovation policy is still on the works as of 2020. Championing a Technology Park in this challenging environment is therefore a display of Entrepreneurial Ambition.

Over the years, ambition was manifested in the form of expanding the scope of the park. Both in terms of expanding the types of residents that can be housed by PTEC-UFRJ, as well as expanding the scope of services provided for these. Details of such expansions will be provided further down in this section as evidence for entrepreneurial versatility.

One of the main objectives of the park is the inclusion of “associated” companies, for PTEC-UFRJ to provide its services for companies not physically located within the park’s land. This movement would greatly expand the scope of companies that can potentially be reached.

[...] we established a strategic direction that is the “overflow”, which means [...] we do not refer to the Technology Park as a physical area, the Technology Park, in reality, is what it does. It does what it does at [the campus], but it can also do what it does now at the Biotechnology Pole, downtown... We are now going to Macaé, we have a partnership with China. So the park is what it does, wherever it may be. [...] (Interviewee D)

Naturally, there is a strengthening pressure for this to be done, as the land area available at PTEC-UFRJ is finite.

[...] the truth is that if we are competent, and successful in our agenda, the 330 thousand square meters will be exhausted, the park will be fully occupied [...] (Interviewee A)

However natural this pressure maybe, the fact that the park has already formally set a goal to achieve this expansion prior to being forced to do it, by the lack of available area, shows an ambitious view of the future.

Figure 19 shows the majority of the major efforts observed at PTEC-UFRJ to display versatility. It starts in 2009, when the first company joined the park. Prior to 2009, there were no resident companies, and PTEC-UFRJ was still concentrating efforts into realizing its original proposition: to attract companies willing to build R&D facilities at the available blocks of land area in order to benefit from the proximity to the university.

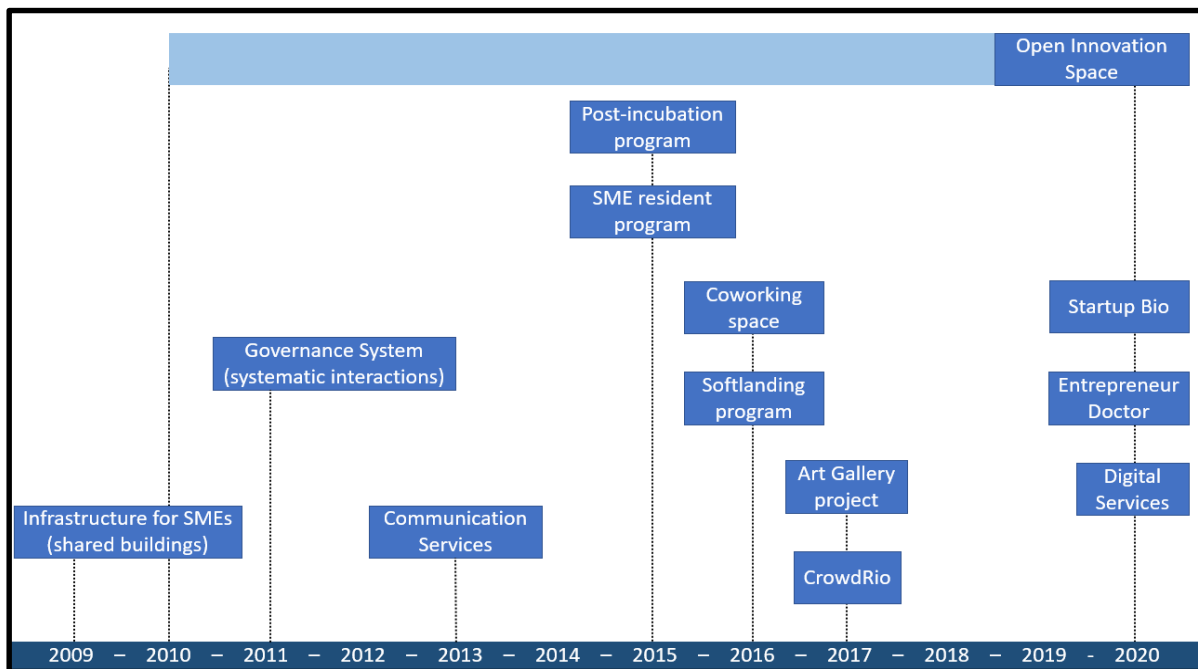


Figure 19 – Evidence of Enterprising at PTEC-UFRJ
Source: created by the author based on PTEC-UFRJ's annual reports

The first item in Figure 19 concerns the building of infrastructure for receiving SMEs as resident companies into shared buildings. One of which is an office building (CETIC), and the other one is divided into semi-industrial sheds (MP), called “prototyping modules”. These buildings made it possible for the park to attract SMEs, as the previous state of the park would require companies able to invest into building their facilities into the land blocks offered by the park. These resulted from environmental opportunities related to the pre-salt rush, but nevertheless the positive results from such opportunities would not be realized should PTEC-UFRJ have not pursued them. PTEC-UFRJ’s Master Plan, approved by UFRJ in 1997, clearly stated that “construction of multi-tenant buildings will be incentivized, with the main goal of housing successful companies, that just came out of some incubation process, but which still do not have the capacity to build their own facilities [...]” (UFRJ, 1996). this

shows that both types of resident companies, large and SMEs, were considered from the ground up. SMEs first appeared, as per the quote above, in the form of recently graduate businesses from incubators. Such buildings were not part of the original plan per se, which simply indicated that the existence of such buildings should be pursued by the park. In fact, they came into existence over a decade after the approval of the park's Master Plan. Therefore, park's management displayed both Entrepreneurial Ambition and Versatility in visualizing the possibilities for potential types of residents, identifying the required resources, and pursuing this objective to its concrete realization.

The historical description of these events, according to interviewees, is the following: around 2007/08, with the pre-salt rush kicked-off by Petrobras, this company entered a cycle of higher investments in R&D. Part of these investments was in the expansion of their research center located at UFRJ (CENPES). As a result, a partnership between COPPETEC, Petrobras and PTEC-UFRJ arose:

The history itself is that Petrobras needed logistic support for their team, for the focalization team, people who were taking care of CENPES construction, and [...] some auditioning teams. They needed a location for these people to be installed. And Petrobras' construction process was much slower than the process of construction through COPPETEC, the COPPETEC foundation was more agile for contracts – for bidding –, these constructions than Petrobras themselves. So this agreement was made between Petrobras and the foundation for the foundation to manage construction of these two buildings... Actually three, right? Because the management building is also included. The management and restaurant building is included in this package. So first CETIC was built, then MP, then the management and restaurant building followed. This timeline, let's say... all of these constructions didn't exceed two years, so 2008 or 2007, and don't have this fixated in my mind, which were the dates. [...] (Interviewee B)

Under this partnership, Petrobras would utilize the buildings during the process of expanding CENPES, and later on gradually release the buildings until fully transferring them to be managed by COPPETEC, as facilities to be utilized by the Technology Park.

[...] They were 100% financed by Petrobras. [...] It was all based on the same agreement that companies undertake inside the park. They built it, used the facilities for some time, and there was an agreement: "you make use of it, the building can be used by you, but after some time, at the end of the agreement, it has to be given back to UFRJ, it has to be given back to the park as the representative, as the user, of that space". So these buildings were given back to the foundation, the foundation is the manager of these buildings, under the figure of the Technology Park. [...] (Interviewee B)

These buildings were gradually transferred back to the foundation starting in 2009. Later on they were redirected for two uses: two shared buildings for receiving resident SMEs (CETIC and MP, as mentioned). And a third building was transformed mainly into the park's management office (housed by the business incubator at that point).

Over the next few years, more SMEs joined the park under this infrastructure. This pushed the park into **expanding the scope of its services**, giving attention to the specific needs of SMEs. In another display of versatility, in 2015 PTEC-UFRJ structured two programs to support SMEs in more ways, beyond articulation services and informational/networking events: the Resident's Program and the Post-Incubation Program. Both programs having a similar scope to that of business consulting: the park would closely observe the companies through regular meetings in order to diagnose areas in which help was needed (in areas such as finance, accounting, strategy, human resources, etc), following on with plans of action to tackle detected needs. This is a clear example of versatility, as the park, originally, did not provide such business support (consulting/mentoring) for SMEs.

[...] We had some installed companies, but we did not provide any kind of advisory service for them. No advisory, no consulting, no mentoring, nothing. And we realized that there was a very obvious flow from companies coming out of [COPPE's] incubator entering the park. And the park, without the services directed to SMEs, ends up being a very hostile environment to the small company. Because they come out of the incubator, where they are completely assisted, and, in a way, protected, and they have an entire set of services attached to it, some support. And then they are not assisted anymore, so they suffered a lot of pain [...] (Interviewee K)

The major difference between the Resident's Program and the Post-Incubation program being that post-incubation was a closer relationship, with higher frequency of meetings and interactions between the park and the resident SME. Furthermore, the programs were divided into collective and individual measures:

[...] If I've got, for instance, ten companies at the park, and all ten present financial management problems, we would create a collective program to try and address this demand. If I found out that one company was facing some issue, for instance, related to HR, I would have punctual measures for this company, to try and help them solve that problem. So, we developed both bigger, collective, programs, to try and help common demands, and, also, punctual support for those specific matters of each company [...] (Interviewee K)

A doctoral dissertation was produced with more in-depth analysis of the structure and impacts of such programs, see Salomão (2019). What is relevant for the context of the

enterprising challenge and versatile capabilities of human resources at the park is the scope of such support services:

[...] [we] analysed the companies in all business dimensions: financial dimensions, human resources management dimensions, productive development, innovation, strategic matters... So [we] tackled six management dimensions with the companies [...] (Interviewee K)

Therefore, not only is the offering of this new type of service a sign of versatility, but also the wide scope of the service in itself.

Similarly, partnerships for Softlanding programs with other Technology Parks (Tecnopuc, Porto Digital, and Tsinghua), expanded ways for the park to receive SMEs, and expanded the scope of services to be provided by the team. Softlanding programs require additional sets of business support services: companies that may arrive through such programs are concerned with testing the applicability of products on a different market, understanding a new geographical environment in terms of market variables (competition, potential partners, etc) and institutional differences (laws, standards, etc). Support in these areas is therefore yet another expansion of scope of capabilities that would be available at the park.

In addition to business consulting services, the park also integrated another service for its SMEs: communications. This was consolidated in 2014 when the formal area of Internal and External Communications was established:

[...] It was in 2014. [Before that], there was nothing, it was just three interns. And then Maurício [said]: “hey, I need to bring visibility to this place”. Then we began to structure a [communications] area for real. We hired a more senior journalist to work on publicity, a person for social media only, [and] a designer to try and give us a more audacious face [...] (Interviewee C)

The Internal and External Communications area, among other things, also serves resident companies by publicizing their activities. This service is more relevant for SMEs, as large companies will usually have their own communications agencies, whereas SMEs commonly will not possess internal teams and capabilities to work on communications, especially if we consider traditional forms of media such as television, newspapers, etc. The main objective of a Communications area in the park was not to offer publicity services for resident companies, in fact, publicity was offered only to the extent that it would serve to showcase innovations that were achieved within the park’s ecosystem (not a general service where companies could request the park to push

publicity of arbitrary matters). But it is here mentioned as nonetheless an additional service available to resident companies.

Following on in the same line of expanding the scope of services, prompted by the incorporation of new target groups under the umbrella of PTEC-UFRJ, are the programs aimed towards individual entrepreneurs and nascent business ideas (at times referred to as pre-incubation or acceleration programs). Three main efforts in this area are: CrowdRio, Startup Bio, and Entrepreneur Doctor.

CrowdRio was the result of a partnership between PTEC-UFRJ and the telecom giant Telefónica, kicked-off in 2017:

[...] CrowdRio is some kind of pre-incubation program, it took ideas fresh out of the oven from really young entrepreneurs. Many times they were just constituting the company [...] formally, at that moment, to enter the program. [...] Telefónica has an accelerator, Wayra, and they did this: they started to replicate their acceleration model, outside Wayra, in other states, through partners. And we were Telefónica's official partner here in Rio de Janeiro [...] (Interviewee K)

The final aim of this program was to act as a filter for ICT startups to ultimately enter Telefónica's accelerator, Wayra. Entrepreneurs with new ideas for digital products, such as marketplace apps and platforms, were selected to enter PTEC's coworking space, and receive support to develop their ideas and enter the market, subjected to periodic assessment of their performance regarding specific targets set to be met during four months cycles. Telefónica provided the acceleration model, but PTEC was solely responsible for implementing the steps set forth in the model, while Telefónica took part in the periodic evaluations. CrowdRio ran into PTEC-UFRJ for two cycles, but ultimately was discontinued and did not result in any of the entrepreneurs being selected to enter Wayra. The existence of this program was nevertheless important because the park acquired experience with yet a new type of target group. With the programs for SMEs, the park offered business support for somewhat already established businesses, that already had finished products, some level of market penetration, and the bureaucratic steps of formalizing as a business figured out. With CrowdRio, the park offered business support for nascent ideas, and dealt with potential entrepreneurs that needed support with introduction to more basic business matters:

[...] it was so that [we] would have a program for that type of nascent entrepreneur, who just had an idea and needed some support like: "what do I do now? What is this world?". We took [them] by the hand for real, from "look, this is what a company is, this is how you should behave, this is how you transform your idea into a product, what is the market" [...] (Interviewee K)

Despite CrowdRio being short lived (also due to changes internal to Telefónica), PTEC-UFRJ went back to engaging with such target group in 2020 shortly after the closing of CrowdRio. Startup Bio was run through May and June of 2020, and arose out of a partnership between PTEC-UFRJ and Sebrae/RJ for a fast pre-acceleration program targeted at entrepreneurs with nascent ideas (ideation phase) in the realm of Bioeconomy. Selected applicants were granted support for business modelling and validation, with the help of a team that included PTEC-UFRJ personnel, as well as Sebrae's consultants. On a similar venue, but focused on graduate level entrepreneurs, is the park's participation in Faperj's Entrepreneur Doctor (Doutor Empreendedor) program. By being one of the institutions certified by Faperj to conduct the program, PTEC-UFRJ can receive PhD-level researchers who wish to apply results of academic research into the market. These entrepreneurs contact the park to get a letter of acceptance, and must enter a public selection process conducted by Faperj in order to join the program, which grants financial funding for research on monthly stipends, in addition to a possible one-time financial grant for investments in necessary equipment. PTEC-UFRJ can also receive monthly stipends for each PhD researcher housed under this program, to account for the support to be provided for the entrepreneurs. The program is an initiative of Faperj, PTEC-UFRJ being one of the participants. However, because the park is embracing the possibility of servicing such target group, a hint of entrepreneurial versatility lies therein. It is worth mentioning that Faperj's president over the period in which this program was created is Maurício Guedes, founder and former General Director of PTEC-UFRJ. Receiving such nascent entrepreneurs was eased due the implementation of a Coworking space at late 2016, and PTEC-UFRJ's embracing of digital media (e.g., Startup Bio was conducted digitally).

As previously mentioned, the park is planning on expanding the pool of companies to which it can provide services by creating a category of "associated" companies, which need not be physically located within the park. To this day, PTEC-UFRJ still has not acquired companies under this model, which may be enough to show ambition, but less so in terms of concrete versatility (if such expansion is as of yet not realised). However, the park has already engaged in some form of ad-hoc articulations with external companies, even if not effectively acquiring a long-term

relationship in the shape of a formalized (contractual) inclusion of those companies as associated to the park. Two examples of such articulations were provided during interviews:

[...] For example, regarding serving the ecosystem, the respirator project, that you may be hearing about [due to the pandemic], from a professor at COPPE: some ten days ago Itaú knocks at my door – many times we end up being the face of the university, for working in this mediation –, so Itaú wanted to know more about the project. Then I went and found the professor and we scheduled an interaction. To summarize, at the end of last week Itaú decided to make a sponsorship, a donation, of one million Reais to the professor's project. The professor is not at the park, Itaú is not at the park, but I feel obliged to make the connections regardless of this formal relationship of Itaú being or not being a resident, or of the professor already having an established relationship with us. [...] (Interviewee A)

Itaú is the biggest Brazilian private bank, and has no formal ties to the Technology Park or to UFRJ whatsoever. Regardless of this, PTEC-UFRJ was able to successfully work into articulating an interaction between Itaú and the university. Although this was an ad-hoc solution, not resulting in a long-term relationship in the form of acquiring an associated company, it is evidence that PTEC-UFRJ is in fact open for expanding into servicing non-resident companies. Another example can be seen in the relationship with L'Oréal. L'Oréal is not formally a resident company at PTEC-UFRJ. It is not located within the park's boundaries (although close), and has no formal contract with the park. It belongs to the "greater innovation ecosystem" of the university for its physical location (in a similar fashion to that of Petrobras, for instance), but a distinction has to be made between companies that are within UFRJ's ecosystem, and a subset of those, who have a formal, contractual, relationship to PTEC-UFRJ (and, as of today, located inside its lands).

[...] there was potential [for interactions], even not being physically at the park, there we call it "the greater ecosystem" [...] (Interviewee E)

Like Petrobras and GE, L'Oréal is formally external to PTEC-UFRJ, part of this greater ecosystem, but the park has made many moves over the years to develop a recurring relationship with these companies. We take the example of L'Oréal, with which PTEC-UFRJ has performed a number of interactions over the years:

[...] I just looked over my table and saw a L'Oréal product and remembered L'Oréal: Last year two professors from [the health sciences school], who were developing a specific technology, looked for me and asked me to present them to L'Oréal, because they thought that the technology had much value to L'Oréal. So ok, I made this channel with the researcher [...]

[...] L'Oréal is a company which is not formally a resident, but I interact a lot with L'Oréal. So [L'Oréal] is in that agenda I told you about, the park serving the ecosystem. It is not a resident company, it doesn't pay any fees to the park, it is not under the contractual obligation – the cooperation clause -, but, still, it is a company which demands a lot from me. And I understand that I have to do it because I “wear UFRJ's hat”, in this university-industry interaction. [...] (Interviewee A)

This situation brings to light an additional level of complexity in analysing entrepreneurship in organizations operating under the Triple Helix intersections. As Enterprising is related to pairs of value-creating and value-capture, meaning entrepreneurship should result in the capture of value by the organization, hybrid organizations may at times pose a conundrum in situations like these. In the examples above (Itaú & L'Oréal), no evidence was provided relating to value being captured by the park, instead, value was captured solely by the university and the companies involved. Due to the hybrid nature of the park, and especially due to its position (institutional form) as one project which belongs to (is inside) the university, value capture by UFRJ can naturally be seen as a proper outcome of entrepreneurship at the park. Naturally, some level of value has to be captured and kept inside the park itself, to allow its operations and, possibly, expansions. But the concept of value-slippage (Lepak, Smith, and Taylor, 2007) may be seen as natural and desired when occurring from the park to the university, which is exemplified by the quote above, where the interviewee states their duty to serve UFRJ's ecosystem as whole, because they “wear UFRJ's hat” – the park is not separated from the university.

We could observe versatility also in the development and implementation of the park's governance system, around 2011/12. The governance system is a structured process designed to increase the rate of interactions between companies and the university. Naturally, the goal of achieving such interactions was at the heart of the park since its inception, but it doesn't necessarily follow that systematic procedures to increase interactions would be set in place to dynamize those. Examples such as Vedovello (1997) show that the question of how does physical proximity, per se, constitute a strong enough force to establish research interactions - between universities and companies at Technology Parks -, has been an important one in the literature surrounding innovation. Whether intended or not, on a first moment, the park operated under the proposition that physical proximity would naturally provide incentives for interactions. Later on, at the beginning of its growth phase, management

decided to pursue more systematic approaches to spur interactions, resulting in the implementation of what they called the “governance system”:

[...]this conclusion that it is not enough to have companies close by, because this does not guarantee that they will interact among themselves, and it is also not enough that they are located [at the park], because they will not automatically interact with the university. We needed to create channels for this. So the governance system came to try and build this framework, let's put it like that, of how these interactions could be done. And thus we created some elements, for instance, we said: “hey, we cannot afford this guy to be here and only talk to him once in a while. No. We need a routine meeting process, where we will help him to find, inside the university, the opportunities [for what] they need, and vice-versa” [...] (Interviewee D)

There is not enough data collected from interviews to assert if operating under the proposal of physical proximity, solely, to create interactions, was intended as of the park's original planning, as it could simply be that an influx of resident companies, and financial and human resources, was being waited on before structuring some previously intended plan of systematic interactions. The original Master Plan for the park, approved by UFRJ in 1997, did mention that interactions between the university and resident companies, for matters related to research, are the essence of the park, but did not go into details as to any systematic approach to such interactions.

Later on, this governance system later underwent changes as the park observed its outcomes and addressed some issues found. A time-limited contractual clause for mandatory cooperation was introduced based on a minimum monetary valuation of such cooperation projects. Additionally, the park worked on pre-defining various forms of cooperation that can be performed.

[...] Even with a system in place to stimulate [interactions], it is still insufficient. So we decided to create a [contractual] clause, which is a clause for mandatory investments in cooperation [...]

[...] one of the problems that we found during the process it had the measure we established... initially it was three million per year... I mean, one million per year... one and a half per year, divided into five years, something like that. [...] Where did that number come from? That number was, in a way, arbitrary, based on the observations we had from a specific industry, and this specific industry was the oil & gas industry [...]

[...] And then we observed that for some companies it was working alright, for others, not so much. And one of the reasons, we understood, was that this Ticket was too [expensive]. So, in a given moment, we lowered the Ticket. So instead of five years, we made it ten years and diluted this thing. As for the small and medium companies, we created a score system [...] (Interviewee D)

From one perspective, these may seem simply as bureaucratic measures that can be linked to a variety of organization growth models such as Greiner (1998). The

link to Entrepreneurial Versatility is made here as follows: first, it is in the essence of PTEC-UFRJ to articulate interactions between the university and its residents, as show the park's 1996 and 2020 mission statements (presented at its website) :

“To approximate the academic world to the business world. To foment the creation of innovative businesses” (UFRJ, 1996)

“to strengthen the ecosystem's capacity for innovation, for wealth creation, and the well-being of society, in an environment made of connections of entrepreneurial initiatives and knowledge generation” (PTEC-UFRJ, 2020)

It follows that, even when completely new venues for value generation could be found apart from articulating the academic and business world for innovation projects, the park cannot be expected to deviate from its core mission. In this sense, versatility would present itself as finding diverse ways to maximize such interactions. Table 7 presents the main pre-defined types of cooperation that can be performed by resident companies with UFRJ, to fulfil contractual obligations:

Table 7 – Modes of cooperation between resident companies and UFRJ

Pre-defined cooperation type
Research projects, contracted from and/or in conjunct with, UFRJ.
Contracting training and services from UFRJ
Utilizing UFRJ's laboratories
Donating equipment, products, software licences, services and general resources to UFRJ
Donations for a scholarship fund kept by PTEC-UFRJ
Investments in infrastructure for UFRJ
Sponsoring UFRJ's initiatives (picked from a pre-selected portfolio)
Operational services contracted from PTEC-UFRJ or COPPE's Incubator
University outreach and environmental and social responsibility projects
Supporting UFRJ's academic and cultural events
Contracting UFRJ's Junior Companies, COPPE's Incubator companies or spin-off companies
Supporting projects from UFRJ's students
Licensing 144echnologies from UFRJ
Co-advising dissertation and thesis being developed by UFRJ students
Sponsoring graduate school scholarships for UFRJ's students
Training employees through academic activities at UFRJ
Internship programs for UFRJ students
Non-financial technical contributions (by senior professionals) to research at UFRJ
Technical visits and reception of UFRJ's students and professors for educational purposes

Source: PTEC-UFRJ (201-)

As several examples indicate – contracting junior companies, donations for scholarships, sponsoring cultural events, investments in infrastructure, among others – PTEC-UFRJ clearly envisioned an expanded scope of interactions which, while not directly linked to research projects, do not deviate from the essential mission of the park. Furthermore, such envisioning of possible types of cooperation do not constitute simple bureaucratic definitions for contractual matters, it makes clear, for both the resident companies and UFRJ, some types of interactions that may not be obvious to either party, therefore constituting an invitation for interactions. For instance, projects can be submitted by UFRJ's students, professors, and employees; analysed by a committee; and then presented to resident companies for funding (or other type of support). Had PTEC-UFRJ not made it explicit that such type of interactions are part of their services, UFRJ's internal public could not simply assume that such channel and opportunities exist at the park. Moreover, in creating contractual incentives for companies to engage in diverse interactions (such as investing in infrastructure, donating equipment or software to UFRJ, etc), the park is expanding the scope of value-capture that can be achieved by the university. Versatility, here, is envisioning diverse modes of fulfilling its essential goal, and establishing mechanisms to pursue the realization of those. To be sure, versatility here lies in expanding the scope of the type of interactions, which the park wants to spur and mediate, deviating from research-only interactions by pointing residents and the university to what the park calls “non-obvious interactions”. Surely, PTEC-UFRJ could stick to reserving their team and services to support R&D-only interactions; as such, diversifying the portfolio of interactions cannot be discarded as a display of Versatility.

[...] with the small [companies] we acted upon, for example: “oh, I need Legal, can I not hire an intern? Can I not hire [UFRJ's] junior law company? If I need to work on a marketing initiative, or perform a campaign, could I contract someone from [the Art's School?] Someone from Design that could help me?”. So we tried non-obvious interactions, interactions not only for R&D, and they do see value on it. For example, with COPPEAD [UFRJ's Business School], we have the mentoring program [...] (Interviewee E)

Following the same line of helping stakeholders to find out different ways in which they can benefit from the Technology Park, and ultimately creating demand for interactions that might otherwise not exist, PTEC-UFRJ grew to offer what could be considered a new service (even though data suggested it was not formally structured as a service offering): helping resident companies to elaborate a plan for open

innovation. This was prompted because the park understood that some companies (in general, not specifically at the park) may be interested in R&D&I for various reasons, or may even be used to R&D&I within the company itself, but need support to understand how open innovation could fit within their internal needs. In this situation, PTEC-UFRJ could offer support for companies to elaborate a plan for such open innovation (innovation through interactions with external players, such as universities and startups). This happened organically when a specific company arrived at the park coming from a not developed background in open innovation, although they already performed R&D&I internally. According to some interviews, upon entering the park, this company wanted to improve its innovation capacities by interacting with diverse scientific areas at the university, but lacked a formal planning of how to do so. Even before their R&D facility was built and running inside the park, PTEC-UFRJ started to work alongside the company in order to develop an “open innovation plan”. As the company was used to performing R&D&I projects entirely within the company, without external interactions such as the type performed under a Technology Park.

[...] They already made, let's say, closed innovation, but this interaction with universities, with other companies, was new for them. So much so that, in this open innovation plan that we made, we, the park, worked a lot. [...] But anyways, it was good, because we learned while doing it and could implement that for other companies. [...]

[...] since the beginning I was talking to someone from [the company] to build what would be this plan of interactions with the university, and with other companies, both from the incubator nearby and small and medium companies from the park. I made an action plan directed towards amplifying their innovation directions, for them to have a real open innovation plan [...]
(Interviewee E)

At this point the park acquired a new set of skills to create value for its residents. And indeed, according to this same interviewee, the development of an “open innovation plan” was later delivered to at least one additional company. This could be seen, in fact, as an expansion of value offered by the park:

[...] At the end of it, I was thinking, you know, we were changing our offer already. For [another company] we also did it, with the same objective, to build this plan. So, I guess maybe it could, in fact, change: it would now not be something outside our scope, it would be our new scope. Innovation within the park. Because we observed that this was adding more [value]. [...]
(Interviewee E)

The above mentioned topics relate to Versatility in a number of ways: (a) the park expanded the scope of potential residents, integrating large companies with their own

facilities, SMEs in shared buildings (further split into offices and semi-industrial prototyping sheds), individual entrepreneurs with nascent ideas (CrowdRio, StartupBio, Entrepreneur Doctor), hosting softlanding programs, and ad-hoc articulations with external companies; and (b) the park expanded the scope of services: with the Resident Program, post-incubation program, and the programs for nascent entrepreneurs, PTEC-UFRJ delivered support for business modelling, and consultancy/mentoring like services for different business areas (finance, Human Resources, etc.), including strategy, for companies and entrepreneurs operating in different markets. The scope of services was also expanded when the PTEC-UFRJ realized some companies may need help in discovering and planning ways to engage in open innovation, instead of simply waiting for their demand, and in pursuing “non-obvious” (non-R&D) types of interactions. There seems to be enough evidence to support entrepreneurial ambition and versatility through the history of PTEC-UFRJ.

As for fund-raising capabilities, the context and institutional form of the park need be taking into consideration before further analysis. First, PTEC-UFRJ is a public (governmental) entity, as part of a federal, public, university in Brazil. It is therefore subject to limitations regarding financial operations and funding which apply to such organizations in the country. The main venue through which PTEC-UFRJ can collect funding is through government entities such as FINEP and FAPERJ, where the usual mechanism is in the form of public “competitions”/bidding processes. PTEC-UFRJ has indeed been able to harness resources from such entities over the years. These are usually attached to investments for specific projects presented to the funding entity through the competitive selection process. Two main examples at PTEC-UFRJ were found: the first is the funding for the construction of a facility directed towards open innovation, previously named “Cubo”, this project was originally meant to increase the circulation of people inside the park (later repurposed). The park received resources for this project through FINEP, back in 2010. The second example was in 2015, when the park won a selection process through FAPERJ, it harnessed resources for a project named Living Lab (described during interviews as a type of Smart City project to showcase technologies by applying them inside campus). Figure 16 (section 5.2.3) presented the amount of funds PTEC-UFRJ collected via FINEP for the years 2015-2018, as presented on their sustainability reports. As observed, FINEP grants heavily fluctuate on a year to year basis. In terms of percent participation, it represented 20%,

43.66%, 5.09%, and 41.42% of total financial resources, respectively for the years 2015 to 2018. There are details relating to problems that may arise from these sources of funding (notoriously regarding delays in receiving the funds), but for the purposes of identifying fund-raising capabilities at the park, the information provided here suffices to show that PTEC-UFRJ has been able to harness funding over the years, within the sources that are available to it within legal boundaries. Not to be overlooked was fund-raising required for the park's basic infrastructure construction, without which there would be no park. These resources were collected from the regional government in Rio de Janeiro. Maurício Guedes led the negotiations which ultimately resulted in the local government funding the construction of the park:

[...] They made an agreement and Rio's municipal government understood that Rio's [Technology] Park was a structure... The park's project, in reality, was convenient to the city of Rio de Janeiro, because it would bring, and also incentivize, this tendency that Rio has, which is a tendency for technology, for technology development, for cutting edge technology. So it all was a big agreement between the prefecture, which made the initial investment for the park emerge. And this was a really good agency [performed by] Maurício Guedes, who is really the man... [he] is the man who ideates the park and is the one who made this negotiation and management with the [government], and sold this idea of a Technology Park [...] (Interviewee B)

In a sense, the park also derived financial support through COPPE's business incubator, this is what made the existence of the park possible during the time period in which there were no resident companies at the park, and therefore no income:

[...] The park always lived – survived –, during that time, with the help... with the program... with [the help of] the Prefecture of Rio de Janeiro, which made the urban infrastructure. There was not much to be done, because at the occasion there were no companies, right? The only resident was the Oceanic Tank [LabOceano], which is a COPPE laboratory, so costs were minimal. There were security costs, but that came through resources from the incubator, the business incubator. The business incubator supported the park during this first moment, a moment where there was no one paying [...] (Interviewee B)

This was naturally possible due to a close connection that exists between the park and the incubator, which were founded, and, at the time, still headed by the same person, Maurício Guedes.

A final evidence for fund-raising abilities is in receiving three buildings financed by Petrobras. As mentioned earlier, the two buildings which function as shared facilities for multiple companies (CETIC and MP), plus a third build that houses the park's management team and other facilities, were all possible due to a partnership between

Petrobras, COPPETEC and the park, and, according to interviews “100% financed by Petrobras” (Interviewee B).

In general, there is good evidence to support the existence of fund-raising capabilities at the park over the years, these have to be considered under the strict context of a public (governmental) entity in Brazil, where the main venue for additional funding lies within the government itself.

Finally, entrepreneurial judgement is the last quality of entrepreneurial services as described by Penrose (1959). Related to the equilibrium of taking enough risks in order to expand, while adequately assessing these in order to avoid unnecessary risks. The collected information is insufficient to assess this dimension. It is noticeable that no major negative event could be identified in the history of the park, especially no major negative event that could be traced to the park's own internal decisions. One interviewee was questioned if there were any situations in which they felt that the park's existence was under threat, to which the answer was the following:

[...] Yes, that happened [...] when we realized the park had too many companies from the oil & gas sector, and the sector was in crisis, in 2014, with spillover to 2015 [...] (Interviewee E)

This answer frames environmental changes as the main driver to a perceived risk for the existence of the park. This specific environmental change, of a crisis in the oil & gas sector, was sudden, considering that the outlook for the sector, especially in Brazil for companies partnering with Petrobras, had been mainly positive during the years prior to 2014/15. Due to the pre-salt rush and to elevated oil prices, the outlook for the industry in Brazil was optimistic. It was however very unlikely for economic agents to predict that a crisis in the sector would happen soon afterwards. There is enough evidence to suggest that the park indeed pursued diversification of sectors in order to space the risks of a concentration in the oil & gas sector. This goal was formally specified in their 2016 strategic planning, but diversification of sectors, in reality, never ceased to be part of PTEC-UFRJ's strategy, it has never formally restricted itself to oil & gas companies in any way. Concentration of oil & gas companies happened organically as the park harnessed opportunities from its environment, in the words of one interviewee, they “surfed the wave” which came their way.

[...] at that moment [2008 to 2012], the park got much imprinted with the presence of the oil & gas sector, and we got known as the oil & gas park. It was coined the expression that it was the Silicon Valley of oil & gas, of energy. And, obviously, we would not turn our backs on such relevant prospects as

Siemens, for instance, as Schlumberger, as Halliburton. But we always knew about the risks of [...] concentration. As time went by, all of that which we have seen happened to the oil & gas industry, and we already knew that diversification was important, since always... we always knew that. And then a more concrete diversification agenda happened. [...] (Interviewee A)

The park not only set clearer goals to diversify, but they have actually achieved it. PTEC-UFRJ has expanded its portfolio by receiving residents from different sectors, such as AmBev (Beverages), CETIQT (textile), MJV (technology, innovation, and strategy consulting), among others. In addition to the articulations mentioned before with external companies such as L'Oréal (cosmetics) and Itaú (bank).

If there is not enough information to assert the presence of entrepreneurial judgment as strong, there is enough to, at least, not assess it as weak, for no major threats to its existence were identified in the data and traced back to the park's own internal decisions. In addition, the most relevant threat, regarding environmental changes, has been recognized and actively addressed by the park.

6.2 Navigating into the complex environment

The environment is subdivided into three dimensions for the purpose of this analysis: Institutional (in relation to external stakeholders and regulators, which set the rules of the game), activities (market and competition), and host (the environment and society).

Data suggests that the institutional dimension of the environment has displayed a challenging character over the years, although some change can be observed as of lately. At the time PTEC-UFRJ was conceived, during the mid-nineties, and up to its approval, construction and inauguration, the country lacked legal instruments for regulating innovation through university-industry interactions. This is critical to any Science Park that involves a public university, because, several constraints and added bureaucracies pose limits to the interactions with private-owned organizations, as well as to financial management, among other things. Moreover, the Brazilian legal system's underlying logic reads like "if it is not written, it is prohibited" (Interviewee I), bringing about legal uncertainties that impact organizations operating in the country. Such a scenario has improved considerably with the introduction of the first Innovation Law (2004/2005), and the subsequent updates in 2016 and 2018. These legal frameworks indeed provided much needed grounds for innovation through university-

industry interactions, although they did, and still do, incur in some degree of legal uncertainty (Rauen, 2016). In addition, internal policies for innovation within the university itself have not been deployed in UFRJ during the entire existence of the park (being on the works as of 2020). This internal policy became especially relevant after the 2016 New Framework For Innovation, which delegated permission and operationalization of some interaction mechanisms to be regulated by universities themselves through internal policies for innovation (these include important venues for interactions, such as sharing labs).

Against this challenging backdrop, PTEC-UFRJ was able to harness the expertise historically cumulated within the university, which engaged in innovation projects and university-industry interactions much prior to the existence of innovation frameworks, Science Parks, and Business Incubators in the country. Actually, the relationship between UFRJ and Petrobras for R&D&I projects since the 60s (and especially COPPE's experience with such interactions) were the start-up point of such initiatives. As such, the environment is one of strict regulation, being highly sensitive to changes in the political sphere. For example, government support for public universities and political changes may affect entities such as FINEP, FAPERJ, CNPq, among others. Moreover, legitimacy of the park in the eyes of all groups inside UFRJ is critical for its existence. The park is not a completely independent organization, being part of UFRJ. As such, its existence depends on the willingness of the parent organization to keep it alive. In fact, the park would not be able to deliver its main value proposition of *innovation through university-industry interactions* should UFRJ researchers not perceive it as a legitimate institution.

The Natural environment could not be strongly assessed as either forgiving or challenging, although inhospitable seems to be far from reality. The park does face some pressure, which is generally widespread across all modern organizations, in terms of sustainability. Indeed, the park recognizes that alignment to UN's SDGs (Sustainable Development Goals) is part of the park's identity. The area of Institutional Development, created around 2012, has as one of its main objectives dealing with sustainability matters. Some pressure from the environment was indicated by interviewees, who viewed the park as a late adopter of renewable energy sources, such as installing more solar panels and expanding rainwater capture. Not only society in general, but also potential resident companies may exert pressure. For example,

one interviewee noted that one of the reasons, among others, for L'Oréal not being located at the park, is that the location of the land was not ideal for L'Oréal's planned natural illumination and wind circulation for its new R&D facility. It is also worth considering that general concern with (or attention to) environmental matters, which have been continuously gaining momentum throughout the last decades, could be more accentuated for the oil & gas sector, which is indeed a major part of the park's identity as of today (although the relevance of this was not mentioned by any interviewee).

As for the environmental dimension related to Activities, mixed data could suggest a mostly challenging environment, being at times forgiving and at other times inhospitable. As for the park's early history, starting from its conception and construction, it is again worth noting that the concept of Technology Parks was by no means well diffused in the country. PTEC-UFRJ was among pioneer efforts to bring this unusual - at the time -, organizational type (Hybrid) to the country, with a value proposition centered on university-industry interactions. Adding to these challenges, Brazil has historically ranked low on indicators such as PINTEC (industry innovation), GERD (% of GDP spend on R&D), number of research personnel allocated in R&D&I positions at private companies, output of patents, among others. The flourishing of R&D&I activities in the country is essential to organizations such as PTEC-UFRJ, provided that their main value offer is directly related to these activities. However, there are at least three areas in which Brazil has attained prominence in science, technology and innovation: Agriculture (championed by Embrapa), Aerospace (championed by Embraer), and oil & gas (championed by Petrobras). The pre-salt rush offered a brief window of opportunity, during which the environment could be considered to lean towards a forgiving state. Actually, the park did enjoy a momentum that made it relatively easy to attract multiple large and renowned global companies, exactly at one of those three stronger sectors (stronger in terms of national technology development and innovation). As for the competitive environment, interviewees have observed that a sense of competition between Technology Parks in Brazil is low, and have even suggested there would be some type of "territorial respect". Nevertheless, going beyond Technology Parks, a varied set of entities that offer, at least partially, similar services to that of the park has been present, and growing, in the region. Finally, the internal innovation ecosystem of UFRJ does possess other actors that may, at times

and partially, intersect with PTEC-UFRJ. The university has developed a decentralized innovation ecosystem, however, data from the interviews suggest that such actors are not viewed as competition, as the final goals of innovation and technology-transfer are common to all of them, drawing a picture of complementary entities, instead of competitors. Internal discussions, and attempts to better integrate such entities have been occurring, especially as of 2019 and 2020, for the development of UFRJ's innovation policy, and PTEC-UFRJ's personnel have indeed being active participants in such efforts.

Table 8 – Description of the environment

Dimension	Description
Natural and society	Some pressure related to sustainability, as is general to most modern organizations. We did not find evidence of immediate pressures regarding the natural environment. However, the park has taken upon itself the responsibility of caring for environmental sustainability and improving as possible, in alignment to UN's SDGs. Considering the long-term, this can be understood as an anticipation of future pressures.
Institutional	<p>Non-market pressures are critical. The environment poses strict regulations at both government and university levels, and, at both levels, uncertainty has been constantly present to some extent, with improvements over the last few years. Acquiescence and Manipulation responses have been observed. There is no evidence to suggest the park has refused to comply with regulations. The park has been active in associations (e.g., Anprotec, Anpei, ReINC) that participate in discussing, suggesting, and orienting the development of public policies. Inside UFRJ, the park has also been an active participant of discussions for internal policies.</p> <p>Legitimacy in the eyes of UFRJ, as a whole, is essential for PTEC-UFRJ's continued existence. There is evidence to suggest that this area is somewhat challenging. Compliance, Co-opting and Influencing tactics have been systematically implemented in the park.</p>

Activities	<p>Little to no competition perceived between PTEC-UFRJ and other Technology Parks, where relations tended more towards cooperation and exchange of information.</p> <p>The park's identity has been grounded in being specifically meant for articulations that involve UFRJ (as opposed to multiple universities and research institutes). No actor external to the university has entered the realm of articulations between companies and UFRJ specifically (or largely), suggesting that external competition, in general, has remained low.</p> <p>UFRJ's internal innovation ecosystem has evolved in a decentralized fashion, counting with multiple relevant actors besides PTEC-UFRJ. These are better seen as complementary, not competitors. Still, potential for superposition of tasks, to some extent, exists within this ecosystem, as the ultimate goal of all actors is to generate innovation by harnessing UFRJ's potentials. In this ecosystem, PTEC-UFRJ has acquired a prominent position.</p>
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Source: created by the author

We will describe the environmental dimensions in more detail below, as well as provide evidence and examples of the ways PTEC-UFRJ has dealt with these dimensions.

The natural and social environment has been classified as forgiving. No immediate natural and/or social pressures that could result in ceasing PTEC-UFRJ's existence were identified. Widespread sustainability pressures have increasingly become relevant, in a generalized form, for organizations, globally (as is reflected, for instance, in UN's Sustainable Development Goals). The park has taken upon itself the responsibility for being attentive to such matters, which has to some extent been part of the park's identity over its lifetime, and is being more heavily worked on currently:

[...] so we will begin to make feasible somethings which I think our park is behind on. Which is to use, for its own consumption, alternative energy sources. To install a bigger set of solar panels, rainwater capture in some buildings which do not have this system, and begin to work some things in which we are falling behind. To walk a little bit towards environmental sustainability [...] (Interviewee I)

Not only is PTEC-UFRJ attentive to environmental sustainability, but also social responsibility could be observed in different ways. Examples include recurrent events where the park would receive high school students from the nearby communities for educational purposes:

[...] I did that because I really wanted to do it, I enjoyed doing it so much. Some of them stared at their phones all the time, but when I said "how can I

help your mother? How do I get your father out of alcoholism?” everybody would stand up. That changed them a little bit, and brought them closer to science, so it was a hook. If you could attract a gaze from those kids, it was worth it, you know? [...] (Interviewee C)

Until recently, the park also allocated part of its income from resident companies to fund scholarships to high school students. This, however, had to be redirected towards the university due to legal interpretations of external public auditing entities.

In summary, no immediate natural and social pressures risking the park's existence have been found. However, pressures in the long run are pervasive. PTEC-UFRJ has been attentive to sustainability issues over its lifetime, therefore anticipating expected future pressures. In this sense, we assess the park's response in the Natural and Social environmental dimension as adequate.

In the institutional dimension, non-market forces have constantly remained critical for the park to maintain its legitimacy and existence, due to the nature of the relationship between the park and its closest stakeholder, UFRJ. To assess the relevance of each stakeholder, a classification in terms of Miles' (2017) 15 pure and combinatory classes. The table below is our proposed distribution of PTEC-UFRJ's stakeholders in light Miles' classifications:

Table 9 – General classification of PTEC-UFRJ's stakeholders

UFRJ	<p>Claimant-Influencer-Collaborator-Recipient:</p> <p>formal relationship between the park and the university, where the park has a recognized goal to benefit the university through its operations and is expected to abide by its policies and ethical standards. This is not a unilateral relationship as the university may incur in losses should the park cease to exist.</p> <p>“UFRJ's clear and permanent command is preserved throughout the entire project” (UFRJ, 1996, p. 14)</p>
The Government	<p>Influencer-Collaborator:</p> <p>strict regulations, legal uncertainty, and the young age of Technology Parks implies that parks attached to public universities depend upon government support to assure their long-term existence.</p>

Resident companies	<p>Claimant-Collaborator-Recipient:</p> <p>Hold claims due to relationships established through the market. For their long-term physical allocation and investments (large companies) in the park, they are also exposed to effects that lie outside their contractual and market relationships.</p>
Human Resources	<p>Collaborator:</p> <p>Without which value-creation would be hindered</p>
Society (local community)	<p>Recipient:</p> <p>Can be affected by the park's operations</p>

Source: created by the author

The table above is a surface level classification, as all five categories can indeed be split up into sub stakeholder groups with differing pure or combinatory classes. For instance, some subgroups within society could be recognized as Claimant-Recipient, such as the residents of the village that lies next to PTEC-UFRJ (Vila Residencial). These have a formal organization body through an Association of Residents (AMAVILA), to which UFRJ (through diverse representations) does indeed establish a relationship for considering their demands and necessities. The government can be split into municipal, state, and federal levels, as well as into regulatory arms and funding entities, where different classes may apply. Table 9 above was therefore a summarization with top-level aggregate classifications.

The university can be divided into different levels of analysis, for example: the university as an institution (organizational level), the multiple research groups within it (group level), and the individual researchers, students, and employees (individual level). As it turns out, research groups and the individual researchers retain the crucial resources that PTEC-UFRJ needs in order to deliver the core value proposition it markets to companies: potential for innovation through interactions with the university. These resources are represented by accumulated academic knowledge and research skills, which compose the basic inputs for the process of *innovation through university-industry interactions* (interactive as opposed to linear flow of knowledge), in the absence of which, such process cannot take place. We can therefore conceptualize

UFRJ's individuals (researchers, students, and servants) and groups as differing in their quality of Collaborator stakeholders. Those who hold knowledge and skills that could potentially be engaged in projects developed through PTEC-UFRJ deemed Claimant-Collaborators-Recipients, and those who, in the foreseeable future, cannot (or are not willing to) engage in interactions with the park, deemed Claimant-Recipients.

Quite clearly, the relationship between research groups and individual researchers to PTEC-UFRJ (referring here specifically to the core activity of interactions with resident companies for R&D&I projects and services) is heavily governed by non-market forces, being dependent upon institutional regulations (of the research groups and their departments, the park, the university as a whole, and the government), and ethical and social pressures. Willingness of researchers to engage in such interactions is crucial: in case a Technology Park is not legitimized under the eyes of researchers and other academic groups, articulating interactions between companies and researchers will be difficult, directly impacting the ability for the park to deliver its core proposition of *innovation through university-industry interactions*. In addition to institutional regulations, examples such as Owen-Smith and Powell (2001) have argued that cultural factors also shape the willingness of university researchers to engage in interactions with the private sector. The matter of legitimacy becomes even more crucial when taking into consideration that university-industry interactions have been observed in the literature to be a controversial topic inside academia, both in Brazil and abroad. According to Plonski (1995) "it would be naive to expect consensus over a subject which is polemical inside universities in Brazil and abroad" (p. 41). In Brazil, Perlin et al. (2018) and Matias-Pereira and Kruglianskas (2005), among other authors, have confirmed the controversial nature of the topic among members of academia. Abroad, Etzkowitz (1983, 1998), Owen-Smith and Powell (2001), and Shane (2004), have also found the topic to be controversial.

In the specific case of PTEC-UFRJ, indeed, data shows that gaining legitimacy from academic groups cannot be expected as a given, instead, it poses some real challenges:

[...] the most challenging [public] is the internal public of the university. This was, let's put it like that, a constant struggle. For us to be perceived not as the "rich cousin", but as a "cousin" which is part of [the university]. From students to professors, it was hard to make them feel some pride, instead of anger, of

it all. Because they felt very disadvantaged: “well, they have rooms with air-conditioning and flipcharts, and we [don’t]...”. I mean, it is like separate worlds. [...] (Interviewee C)

[...] this is the most interesting thing about Brazilian culture: I need to convince part of the academic community that the process of transferring knowledge for innovation is good [...] (Interviewee I)

Navigating this environment in the dimension of legitimacy has a link with the Enterprising challenge. PTEC-UFRJ has worked on projects that generate value to different groups inside UFRJ, which will be described below. Value captured by the park as a result of these activities comes in the form of normative value (legitimacy). For example, by expanding the scope of types of interactions between resident companies and the university, as valid for the contractual mandatory cooperation clause, the park can generate more value to the university, which in turn can have positive impacts on its legitimacy. E.g., when a company at the park cooperates with the university by donating equipment or investing in infrastructure, value is captured by UFRJ, and this in turn could result in positive effects to the legitimacy of the park.

The factors associated with PTEC-UFRJ’s legitimacy, concerning the groups of stakeholders inside UFRJ, were roughly divided into three potential sources: (a) perceived difference in quality standards of infrastructure and amenities between PTEC-UFRJ and the rest of the university; (b) potential for negative views related to the impacts of private companies inside a public university, and of interacting with them; and (c) not perceiving benefits from the interactions between companies and the university. We emphasise that the data is not sufficient to assert that any of these three sources are pervasive or represent a major part of opinions found at the university in any way or form. The data is simply enough to assert that these challenges to legitimacy exist at some level, but not at what level.

The first item of the list is simply related to PTEC-UFRJ being built and maintained with high quality standards for its infrastructure, amenities, and facilities maintenance. This stands in stark contrast to what is common inside public universities in Brazil, and indeed stands in contrast to most parts of UFRJ itself. The quote above by Interviewee C exemplifies this very clearly, stating that some may perceive the park as a “rich cousin”, instead of one of their own. The quote below explains that such high quality standards are, however, a necessary requirement to match the level of

companies received by the park, but stresses that opinions from both sides cannot be taken out of the equation:

[...] [We] had to reach a baseline, so that the private companies located there not to feel too much of a shock. [...] There was no luxury, it was not supposed to have any luxury, but we had to keep a minimum accepted quality. This has always been our guideline: “we will operate with something that is acceptable for both [sides]” [...] (Interviewee B)

The second item of the list is related to likely perceived negative effects that could arise from the presence of and interaction with private companies inside a university. This is a well-known topic discussed in the literature of innovation and technology transfer (e.g., see Eagleton, 2015; Perlin et al., 2018):

[...] There was a sense that the university was selling out, right? The companies were... a sense that companies were taking over the university. But quite the opposite, I believe that who took more value out of the companies was, is, the university. And it did... the university does, right? [...] (Interviewee B)

The third item on the list is simply the possibility of not perceiving, or even caring about, any benefits that could possibly arise out of interactions between the university and private companies. While some research areas may engage in university-industry interactions often, other areas may not do so much, or at all. As a result, supporting a Technology Park initiative may not naturally come. The quote below illustrates this quite clearly:

[...] basic research, right? Which does not have very strong interactions with the market. So it is harder to... Not necessarily will they be resistant, but also not necessarily will they support it. Because they do not do it on their daily lives, they do not see it as an important matter [...] (Interviewee J)

Proper response to the challenge of navigating the environment requires that mechanisms for acquiring legitimacy be set in place, necessary to avoid the proliferation of pressures from stakeholders that could drive the organization out of existence. To deal with this dimension of legitimacy, PTEC-UFRJ indeed has set formal structures in order to establish communication channels and to create relationships and partnerships with the university's internal academic groups.

To recall: the relationship between the park and other parts of the university can be split into at least two different dimensions, the first encompasses articulations for interactions between companies and the university for R&D&I projects, this is attributed to the Corporate Articulations area. The second dimension of this relationship is between the park and all parts of the university as a whole, regardless of which

departments, researchers, students or laboratories currently do, or in the past have, interacted with the park and/or its companies for R&D&I projects. This is the dimension of legitimacy; it deals with the acceptance and support, by the general groups inside UFRJ, for the very existence of the park. This is explained in light of Miles' (2017) stakeholder classes: some individuals in the university are *Collaborators* to the park (i.e., take part in interactions through the park, or other support roles), but all of them are also *Claimant-Recipients*, regardless of currently being Collaborators or not. In light of Fleck's (2009, 2010) proposals, as the latter group also occupies the position of legitimate stakeholders, managing the relationship with said group will also impact acquisition of normative value. Our data provides enough evidence to assert that PTEC-UFRJ has been adequately active in managing such relationship, the details will be provided below.

Dealing with this last type of relationships is pervasive across most teams in PTEC-UFRJ, but there are indeed some formalized structures in the park that have a clearer emphasis on connecting with the university for acquisition of normative-value. One of such formalized structures is the *Internal and External Communications* area, created in 2014:

[...] [creation of the communications area] was in 2014. [Before that], there was nothing, it was just three interns. And then Mauricio [said]: "hey, I need to bring visibility to this place". Then we began to structure a [communications] area for real. We hired a more senior journalist to work on publicity, a person for social media only, [and] a designer to try and give us a more audacious face [...] (Interviewee C)

As is well reflected in its name, the Internal and External Communications area was tasked with dealing with multiple target groups, among which was UFRJ's internal academic groups (students, professors, and employees alike). By publicizing successful stories of innovation (and of other projects that may generate benefits to the university) through different media platforms (traditional media such as television, and digital media, such as social networks), the park increases its capacity to positively impact its legitimacy in the eyes of all stakeholders, including internal groups at UFRJ.

An additional formal structure is the area named "Institutional Development", created a few years before the communications area. Institutional Development resulted from splitting the original attributions of the Corporate Articulations team:

[...] When I arrived there, there was this [area named] Corporate Articulations, which basically took care of, I mean, everything. Of government relations, fund-raising, project management, prospecting companies, observing the

relationship with these companies. In other words, they did everything, everything that was, in-fact, core-business at the park, right? Because these other [areas], operations, projects, management, etc., are line areas, right? Things we need to do the job. And then there came a moment in which this Articulations area got too inflated, there were too many attributions over it. [...] And then we [mapped the] processes of this area, so we assembled the area. And, when we did that, we realized there were a series of tasks that were not exactly aligned, you know, with the purpose of that area. That was when I proposed for us to create a new area, which we called Institutional Development. It concentrates, basically, on three pillars:

The first is strategic management, so we think the park of the future [...], where does the park want to go. [...]

There is a second layer which we call “promoting the innovation ecosystem”, it is in this realm that we create projects. So, for instance, we have innovation projects with diverse areas of UFRJ. We work with the arts school; we created a public art gallery [...]. So we want to have a human environment, humanized, liveable. A place where people like to stay. [...]

And, finally, there is a third vertical, which is sustainability. In this realm we work projects that are related to the environmental, social, and, evidently, the economic dimensions too. [...] (Interviewee D)

This second pillar attributed to the Institutional Development area (“promoting the innovation ecosystem”) is related to the legitimacy PTEC-UFRJ has in the eyes of the university in general. In the realm of Institutional Development, projects are made with the university in matters other than R&D interactions with companies. Projects in this area can even depart from technological topics, entering social, cultural, and environmental projects. This can reach parts of the university that otherwise would hardly interact with PTEC-UFRJ had it remained exclusively focused on technological R&D&I projects (for example, the public art gallery mentioned by the interviewee above).

Data is sufficient to assert that PTEC-UFRJ has indeed developed multiple projects in order to work on this general relationship with the university. As a first example, we can point to the stakeholder group of students in the university:

[...] when you talk about undergrad, there was a higher [level of] difficulty. They could not capture that enterprising was also an option for work, right? [...] The undergrad student was a little bit more... [the word] is not resistant, they were a bit more sceptical, maybe. Graduate [students], however, were easier. [...] Graduate level was easier for us. Also because there was already some laboratory action, the mentality was different, they were more inclined to this. So when we approached professors and students, we had more of an opening [...] (Interviewee C)

Some of the efforts done to increase proximity with students include: (a) vouching for an academic chair (course) on innovation at UFRJ, (b) articulating resident companies

to offer educational content in the form of classes, (c) stimulating resident companies to offer opportunities for students in the form of internships and by co-advising graduate research, (d) integrating students within the park itself, by prioritizing them as potential hires.

[...] We created a program, for instance, to take the park into the classrooms, and even to fight for an innovation chair. Because... I mean, what did we want when a student got into the university? "Look, you can study, research, start a business, and work in this university" [...] (Interviewee C)

[...] Schlumberger acted [on it] a lot, they acted even in [the form of] holding classes inside the university. [...] This experience was transmitted to students and formed better professionals. [...] (Interviewee E)

[...] we tried to make a more robust program, that would involve many companies. We were even talking to the... it was Oil Engineering [...]. So we talked with Oil Engineering, it was professor Paulo Couto by the way, about creating a course that would encompass, in multiple class sessions, these practical experiences. So they [the companies] would go there and talk about how things happened in the industry, to provide the theory while also showing practical examples... [...] (Interviewee E)

No details relating to the program mentioned above were collected during interviews, however at least part of the project was indeed successfully put to practice:

[...] Well, I do not know how things went there. If they were able to go forward with it [...]. Actually, we did manage to implement it, there were some classes, but I do not know if we managed to reach the entire scope of it. [...] (Interviewee E)

In addition to bringing some companies to classrooms, a link between students and the park was also made by bringing students into companies, providing research opportunities for graduate level students

[...] another thing that also happened, for instance... but then it was not necessarily undergrad students, it was also graduate students. At Dell this happened: there was a research contract directly with these students, I think PhD students in this case. They stayed for some time doing this research, under the supervision of advisors. That is how it worked. And that research would serve for that student's dissertation, or thesis, and then he could be hired. So this also happened, these were some examples [...] (Interviewee E)

As mentioned earlier over the Challenge of Enterprising, resident companies have an incentive to provide such opportunities to students through the contractual clause for mandatory cooperation, observing that PTEC-UFRJ has explicitly informed that such opportunities to UFRJ's students are also included in the modes of cooperation and count as partial fulfilment of the contract .

The following table has some examples of programs PTEC-UFRJ has developed (by itself or in partnership with other entities in the university) which established a relationship with, and benefited, students in the university:

Table 10 – Sample of PTEC-UFRJ's projects for students

Project	Description
UFRJ Desafia (UFRJ Challenges)	Group for uniting student teams from the engineering school that represent UFRJ in diverse national and international competitions (for example, robotics team, aero design team, and more). The teams meet frequently to exchange information and support each other. PTEC-UFRJ has at times provided financial support in the realm of this project (for example, sponsoring a team's costs to join international competitions)
Esporte Representação (Sports Representation)	In partnership with the physical education and sports school, this program supports teams of sports in the university to participate in regional and national competitions.
Gilberto Velho Prize	Created in 2013, this was a yearly prize given to five PhD dissertations from different academic areas. A ten thousand reais prize was given to all five winners and their advisors had PTEC-UFRJ sponsor travel expenses for one scientific event.

PTEC-UFRJ (201-)

Considering all components of the university, not only students, the table below provides some examples as evidence that the park has developed projects to tighten its relationship with stakeholders in the university in multiple occasions:

Table 11 – Sample of PTEC-UFRJ's general projects with UFRJ

Project	Description
"Curto Circuito" public art gallery	Created in 2017, in partnership with the school of arts, the park has open expositions of works of art made by professors and students, in addition to artists with national and international recognition.
Memórias do Boto (memories of the Dolphin)	Before the continuous art gallery project, PTEC-UFRJ had performed a one-off art project in 2015, on a partnership between the park, the art school, and the naval engineering laboratory. The engineering group provided glass-fibber sculptures of dolphins, and these were decorated by professors and students of the art school with specific themes.
Sponsoring students for the Cannes film festival	In 2017, the PTEC-UFRJ sponsored travel costs for two students of the Communications School who were selected for screening at the Cannes festival, in France.
Sponsoring a UFRJ competition for sustainability projects	In 2014, the park sponsored prizes for the winners of a competition made by UFRJ for sustainability projects to be applied inside the university. The competition had students, professors and employees participating.
Gastronomic fairs	Starting in 2016, the park held multiple gastronomic fairs, a partnership with UFRJ's Gastronomy school. Food enterprises from students were present, and the event also had presentations made by other groups of the university.
Environment Week	Starting in 2015, PTEC-UFRJ holds a yearly bundle of events over three days named the environment week. Presentations on topics related to sustainability are delivered by professors of different departments in the university, members of government entities, private companies (both resident and external), and the park's team. Activities such as planting seeds are performed.
Affirmative Actions Prize	Yearly selection of five academic works developed in graduate level programs of the university, in areas related to inclusion of marginalized groups. PTEC-UFRJ offers cash prizes for the winners.
Affirmative Actions Scholarship funding	In 2018, a program was developed for funding scholarships to graduate students in multiple programs in the university. The scholarships are directed to students that join the program through affirmative actions, and are funded by the park.

PTEC-UFRJ (201-)

It is not claimed here that such projects of interactions between the park and the university, that lie outside the realm of interactions for technological R&D&I, are

made with the main purpose of sustaining legitimacy, only that normative value can be captured as a by-product of such interactions. To better exemplify: there were instances in which PTEC-UFRJ contracted entities inside the university to deliver services needed by the park (e.g., a Junior Company of Psychology for HR related services, a Junior Company of engineering for electrical planning services, a group from the engineering school for structural integrity checks, etc). While it is possible that such services could be contracted from the open market, outside the university, such preference to the university can both deliver the services needed by the park and have a positive impact on its relationship with UFRJ as a stakeholder.

In addition to these partnerships with the university that go beyond R&D articulations with resident companies, the PTEC-UFRJ recognizes that transparency is a key factor for its legitimacy (this time not only in the eyes of the academic community, but of its stakeholders in general):

[...] One of the principles for us to gain trust from the players, for them to choose us as a facilitator, they need to trust us. For them to trust us we need to show ourselves to them. And we need... we cannot be ashamed of ourselves. So, look, when I say "here, we are improving, we managed to do such and such, we were not able to do this", we are saying "well, come and help us improve". [...] (Interviewee I)

Illustrative actions in this direction include: (1) in 2016, PTEC-UFRJ started publicizing annual sustainability reports based on GRI (global Reporting Initiative) standards, for the previous year, these were made available both in Portuguese and English in subsequent years; (2) in 2020, the park started the public release of performance reports, with more comprehensive descriptions of each individual area's activities and performance indicators; (3) in 2015, the park opened up a description of its costs and expenditures for resident companies; (4) to justify its decision of not outsourcing infrastructure maintenance personnel, in 2020 the park released a description of their cost, with comparisons to what the cost would be if outsourced (this was made voluntarily as management decided such decision need to be legitimized).

There is enough evidence to suggest that PTEC-UFRJ has been aware of the challenges related to its legitimacy, and that its position cannot be described as passive.

Still regarding the park's legitimacy in the eyes of UFRJ as whole, one interesting aspect brought up during interviews was: not every cooperation project, per se, can automatically be considered valuable to the university, and market values will

not necessarily correspond to the value perceived by the university. Therefore, the park's legitimacy not only depends on successfully articulating projects, but also in the university's assessment of the validity and value of such projects. One specific episode illustrates this situation clearly: a resident company offered one of their proprietary software to a professor, who would be allowed to utilize the software in classes with his students. Upon notifying the Technology Park of this cooperation agreement, the company requested the valuation of this single cooperation effort to be accounted for according to the software's market value, about 20 million BRL, which would even exceed the total amount of mandatory cooperation set in the contract for the entire permanence of the company in the park. Because of this episode, a new committee was created in order to evaluate cooperation activities between resident companies and UFRJ, to judge if specific efforts are valid for fulfilling the mandatory cooperation clause, and also to set the value of the project according to the university's interests.

[...] And so this committee makes a "merit analysis", and the merit is what follows: "does it interest UFRJ or doesn't it?". If it does interest UFRJ, green light, and the value to be ratified is also defined by this committee.

You could ask me: "are there cases of projects which do not interest UFRJ?", and my answer would be: "yes, there are cases of projects like this". It is not that they don't interest anyone inside UFRJ, what happens is that, sometimes, it is much more of a specific professor's interest than of the institution itself. The example of the software is one of these. I mean, ok, that professor really wanted to use that software, but the conditions to use the software did not interest UFRJ, right?

At the end of the day, the story of this software was this: the company provided the licenses for use, but the ratified value was zero [...] (Interviewee D)

This existence of this committee points to co-opting tactics, as defined by Oliver (1991), evidence that PTEC-UFRJ has also adopted some of the more active strategies for dealing with institutional pressures and maintaining legitimacy.

Another source of major institutional pressures for PTEC-UFRJ stem from its strictly regulated environment. Mainly, regulations that govern public entities in Brazil – which operate under stricter rules than otherwise observed in private organizations –, and in specific regulations related to interactions between public research institutions and private organizations.

To illustrate the first: As the park lies within this hybrid concept, and is attached to a federal public university, management of financial resources has to obey some stricter rules than what is otherwise observed in private organizations:

[...] now, what I can tell you is hard, even with the companies, when they started paying - when we began to get resources from these companies -, is that the concept... The money was there - the money that got in from the private sector went into the Foundation -, but from the moment that it enters the foundation it turns into something that has to be managed as a public service. So there was a dilemma, right? The money is not public, but as soon as it enters the checking account of a Foundation, which is a supporting Foundation for the university, the rule is... And this was discussed for a very long time, many debates around this: if it was public or not. But the rule is to obey the 8.666 [Federal Law].

It has to be obeyed because it is money, it is a resource, that we have to be held accountable for, for the companies even. So at this moment we become public managers [...], the entire team, the entire staff, reckons that the money exists, it is private, but it has to be managed as public sector money [...] (Interviewee B)

And these limitations posed a number of challenges regarding the application of resources in the park: some bureaucratic challenges pertaining to the actual legal proceedings of managing public money, as well as ethical considerations, illustrated below:

[...] back in the day there was a public servant at the finance area, and she debated a lot: "but if the university doesn't even have toilet paper, you want to buy Neve [premium toilet paper brand] in here? [laughter] But the resources... we are also held accountable by the companies, who were paying for the Neve. I am sorry for the raunchy example, but it is an example that serves well. You have to offer, during a lecture or a meeting, you have to bring water to the guests, at the table, you need mineral water, you wouldn't bring tap water, you would bring a bottle of water. You need a different level of quality, different from what used to happen, of what happens usually, inside the university." [...] (Interviewee B)

An example of such limitations imposed by the public sector rules for managing the money was provided by the interviewee below, regarding the construction of a new website for the park:

[...] the website is not... it is still not good, because we were obliged, through biddings, to hire a company for the lowest price, and the lowest price company went bankrupt. We were stuck in an infrastructure, a network infrastructure, in which the layout could not be changed, so it ended up something a little ugly, you know? So, I mean, we had to deal with internal bureaucratic barriers. [...] (Interviewee C)

Other examples include strict rules and timelines to apply money raised through public funding entities, for specific projects:

[...] One of the biggest hardships of public service is to realize the budget, because bidding time is too long and whatnot and you have to engage the resources. So you make a planning, a Tour de Force with the team: "the resource will go here, we need to make a public bidding for this, this, and that, the problems are such and such, the reference terms. Let's get everything ready!" [...] (Interviewee I)

As these are legal requirements that need to be observed by public entities in general, it seems the only fitting answer would be Acquiescence (Oliver, 1991). There is no evidence to suggest that the park has applied strategies to avoid, defy, compromise, or in any way not follow governmental regulations.

For regulations regarding the specific matter of interactions between public research institutions and private organizations, both governmental regulations and internal university regulations play a major role. The two main pieces of governmental regulations relevant to the park were the 2004/05 Innovation Law and the 2016/18 Innovation Framework that substituted the earlier effort. Prior to 2004, the inexistence of legal tools for interactions between public universities and the industry could suggest an environment tending to inhospitable due to heavy uncertainties and instabilities relating the basic functions of the park. As was observed by the interviewee below, explicit and clear legal mechanisms are of utmost importance in the context of public entities in Brazil:

[...] innovation needs flexibility, ok? I do not like these clichés, but, I mean, the way I feel it, one of the biggest problems is the fact that we live under Latin law. Maybe one of the best things to explain the difference in innovation between countries are the legal models. Because in the Saxon model, if it is not written, it is not prohibited, and in the Latin model, if it is not written, it is prohibited. So to innovate is always forbidden under the Latin model, always. [...]

This interaction between public and private needs, in our legal model, of really well-thought-out rules, because without rules it cannot exist. And to think up these rules, well enough, is as challenging as writing a complete contract, in other others, it is impossible [...] (Interviewee I)

The first major regulation came in 1994 with the Law for Support Foundations (Fundações de Apoio). Ten years later, the 2004 Innovation Law debuted at the federal level to specifically regulate university-industry interactions for innovation. This law formally allowed a number of ways in which public research institutions could interact with private organizations (for example, sharing of infrastructure, equipment, and human resources between public and private institutions). However, Rauen (2016) has pointed out that much legal uncertainty was present surrounding the matters covered by the 2004 Innovation Law, and that it was incapable of “being translated into an effective instrument” (p. 23). Updates to the innovation framework were made in 2016. These solved some issues, but as Rauen (2016), some uncertainty remained.

Data from PTEC-UFRJ confirms that uncertainty regarding the Brazilian innovation framework is in fact an issue that has to be dealt with by the park. To exemplify, there were at least two situations where legal uncertainty was clear and had major impacts. The first example occurred when PTEC-UFRJ incorporated BioRio into its organizational structure.

BioRio is an innovation pole for the bioeconomy sectors (it may be considered a Technology Park in itself) that was linked to UFRJ through the BioRio Foundation, its de facto owner until very recently. It exists since 1984 inside UFRJ's campus, and is actually one of the oldest innovation environments to exist in Brazil. The contract between UFRJ and the foundation finally expired in 2018 and was not renewed. Shortly afterwards, it was decided that PTEC-UFRJ would be incorporating BioRio inside its governance structure.

[...] At the occasion, February 2019, the understanding of the [Attorney General's Office], was that: the companies that were [already] there could present themselves in a public [selection process] made by UFRJ. Because – it is important to know –, these companies had a relationship with the BioRio Foundation, and the foundation had a relationship with the university. These companies never had a direct relationship with UFRJ.

The premise back then was that the companies could present themselves to a public [selection process], and enter a relationship with UFRJ. And we worked on this premise for many months in 2019, to launch an [public selection process], and then these companies would [participate]. Some company that occupies Block A would present itself for a [selection process] for Block A.

Time went by, there was a change in the Dean's office, yes, but also, predominantly, a change in the Attorney General's Office team. And the new understanding, of the new attorneys, is that this would be illegal: we could not launch a selection process for a company which is [already] installed in a physical space, for them to [compete] for that same area, that would be "directing" [...]

This is the current status: the companies are fighting to stay for a longer time, but the position of the Attorney General's Office is this: that they really need to leave before they get in [...] (Interviewee A)

A change in the team of attorneys at the Attorney General's Office unit inside UFRJ, responsible for advising public entities on legal interpretations and defending the interests of the Federal Union, resulted in a completely different understanding of the legal framework. In turn, many issues have arisen out of such change in interpretation. BioRio resident companies are required to completely leave before they can join a public process to hopefully re-enter the park, however, it has been reported that many of those companies have simply decided to move permanently to other

locations. In addition, some companies have launched lawsuits to gain the right of remaining longer at the park. This is especially negative for PTEC-UFRJ as the Bioeconomy sector was mentioned by multiple interviews as one of the park's main interest areas for future growth, due to UFRJ's expertise in this segment.

A second example of uncertainty with major impacts happened in relation to the model that had been adopted by the park to split revenue from concessions evenly for three different ends: 1/3 went into the park's operation costs, and investments, 1/3 went into a scholarship fund, and 1/3 went to a "special projects" fund.

"There was a national auditioning happening regarding the assets of public universities. In particular, some auditors questioned the use of resources originated from the concessions paid by companies installed in the shared buildings, which were distributed equally, where 1/3 of the total was utilized for operations, infrastructure investments, and projects of the park; 1/3 was used to promote special projects in UFRJ's interests; and 1/3 was utilized in the program for scholarships for high school students (PIBIC-EM)" (PTEC-UFRJ, 2020, p. 39)

The Accounting General Office suggested that 100% of these resources should be applied for R&D&I projects. As a result, the park had to go through a process with the Attorney General's Office and COPPETEC in order to change the way in which these resources are applied. As it turns out, this is not as easy as changing the destination of money inside a private organization, and the park had to keep money from this source in a contingency account for some time until finalizing the changes.

Response of PTEC-UFRJ to these regulations seems to also fall mostly within Acquiescence (Oliver, 1991). As no evidence suggested defiance or otherwise departing from the regulations.

Regulation at the level of the university itself is also relevant in this context. The 2016 update to the innovation law has a number of items which are delegated for the research institutions to decide whether they will allow them to happen and, if so, how are they to be effectively operationalized. However:

[...] amazingly, UFRJ, to this day, only possesses a policy for Intellectual Property, it does not possess a policy for innovation. The innovation policy is being discussed [right now] [...] (Interviewee H)

[...] what does the Law do? The Law signals a bunch of stuff that are possible [to be made], one of which is the sharing of laboratories, but it leaves that article I showed you, 15a, for the university to decide upon, internally. So, while the university does not have such policy approved, it is all in limbo [...] (Interviewee J)

UFRJ has a pioneering history of engaging in university-industry interactions much prior to university Technology Parks and business incubators existed in the country, before all of the mentioned regulations mentioned above were even discussed, in the 1970s UFRJ began some form of such interactions, mostly with Petrobras' research center. Most of it was conducted by the graduate school of engineering (COPPE). Various actors involved in UFRJ's innovation ecosystem evolved independently over time, such as COPPETEC, the Innovation Agency, COPPE's business incubator, the Technology Park, and more, resulting in a decentralized ecosystem.

[...] We have COPPE, which already did these Innovation Law things much prior to any law. Back in the 70s we already performed these partnerships, university-industry cooperation agreements. People did not understand very well what that was. So much so that, to this day, people even joke: "oh, there is COPPE and the rest of the university". People think it is a separate thing because, there, in reality, this flow is a common thing already, right? Which is not too common to the university. So UFRJ has this peculiarity.

In reality, I think it is actually easier for newer universities, which are now starting out this innovation thing, to put everything into an organized form and everyone knowing which attributions are theirs, to create this system. In contrast to taking a university which already has its own way of functioning, the way it found to make all of this happen. And then you go there with a Law and say: "now the Innovation Nucleus will have this attribution which is already performed by you here". So UFRJ differs from other universities because of COPPE's history, right? [...] (Interviewee H)

Due to this decentralized development of actors that compose UFRJ's innovation ecosystem, regulating the roles of each entity is difficult, and at times superposition of roles and activities indeed happen:

[...] In reality, these organisms, the park, the incubator, the foundations, will have many points of intersection in these attributions, I don't know: "but I do this, I do this". And nothing prevents this superposition of attributions, right? The more, the better, as long as we are all on the same page [...] (Interviewee H)

UFRJ is working on the first version of its innovation policy as of 2020, and this policy should both fill in the gaps delegated by the federal innovation framework to be regulated internally, as well as better integrate the actors of UFRJ's innovation ecosystem. Data suggests that such decentralization and independency of actors is ingrained in their identity, and pressures tend towards keeping a decentralized ecosystem with the new innovation policy:

[...] the idea of keeping this decentralization has to do also with keeping this history. So the respect for the history, the autonomy, we wanted to keep. And then create mechanisms in which these actors would talk [...] (Interviewee J)

This work has no intention to evaluate whether a centralized or decentralized innovation ecosystem is the better choice for the university. This is simply a description of the institutional environment to provide the reader with greater context detail. We suppose that a lack of an innovation policy and the decentralized nature of the ecosystem may however contribute for a more challenging environment than what would otherwise be true, because uncertainty is greater.

Regarding the decentralization of UFRJ's innovation ecosystem, the park has also influenced some decisions and navigated the environment well enough to assert a more central position. For example, in 2019 a partnership between the Innovation Agency and a professor of the medical school created the concept of INOVAs, they "are like clusters, they are like arms of the Agency" (Interviewee H), to be offices within every major academic department of the university to reach professors and students with demands and ideas related to innovation matters, so that the Innovation Agency could easier reach these people. These structures were naturally part of the discussions on the new innovation policy and PTEC-UFRJ has helped in evolving this idea in order for them to not only serve the Innovation Agency, but to guide the demands towards all actors of the ecosystem on a case-by-case analysis. This way, PTEC-UFRJ would also increase its reach within the university, receiving demands that otherwise might not have come to their knowledge.

[...] At the beginning, these nuclei were thought up as arms of the Innovation Agency [...]. One thing that we proposed and was accepted was that these nuclei would in reality demand from the agency, from the park, from the incubator, and whoever else. So this means their role becomes to capture what are the existing demands for service, from who is effectively at the laboratories, and the nucleus engages whoever they think they should. And the commitment of the other [actors] is to serve. [...] (Interviewee I)

As the park "wants to become a hub" (Interviewee I) within the university, to support professors, students and employees with ideas but who need support into developing them into a business, this movement to shape UFRJ's ecosystem is essential, and this one occasion provides evidence that the park does indeed attempt to shape its environment.

One major challenge for the park, related to regulations, is the nature of its formal institutional arrangement. In Brazil, there are multiple institutional (juridical) forms a Technology Park may take, each with their own advantages and disadvantages (Abreu et al., 2016). As was just discussed, PTEC-UFRJ came to life

prior to much of today's regulations, and this has meant the park has operated under a judicial form which is not well defined:

[...] One of the park's challenges today is the matter of institutional [form]. Because the park was created well before everything, before the legal framework, before anything. So, it was created with the institutional form that was possible [at the time]. What is the park, today? The park is one project from UFRJ inside one of [the university's] support foundations, whose coordinator is allotted in the dean's office. That is all. The park is not an organ, the park is not a UFRJ unit, the park is not an autonomous entity. [...] As one attorney has defined it: "it is a qualified inexistence", if I recall correctly. [...] (Interviewee I)

Its legal form referred to as "qualified inexistence" has been the source of added uncertainty for the park's operations:

[...] oh, it brings many difficulties. [...] Because at times you have to follow the regulations of public service, TCU, etc, etc, etc. But, at the same time, you also have to follow the Foundation's rules, which, in some respects, is even worse. So [we] cannot do a number of things because [we] are the foundation, and only UFRJ can do certain things. But, for the things [we] can do, because it is the foundation, [we] need to follow the regulations of public service. So, this, in fact, results in a more challenging job. [...] (Interviewee I)

PTEC-UFRJ's participation in the discussions for the development of UFRJ's innovation policy has also been concerned with establishing a new, and better defined, juridical form.

[...] one of the things we have already been discussing for UFRJ's innovation policy is to eventually think up what would be a new institutional arrangement for the park [...] (Interviewee I)

To finish up environmental pressures related to regulations, we can consider those that rule the functioning of companies associated to the park as also relevant for PTEC-UFRJ's existence. As was seen in the 2015 crisis, impacts to resident companies could indirectly affect the park.

[...] for example: "I don't know what to do, I need us to unite in this moment in order to approach the state and... I don't know, there is that discussion about Petroleum in which you had to pay with the final product". I don't know, any legal discussion is better done in groups than alone. And the park is a representative of this sector, so we made events for internal discussions, also for discussions that took the path of union [...] (Interviewee C)

In the face of such pressures related to institutional regulations described above, there is some evidence to suggest that the park, at least at times, adopted response strategies other than Acquiescence, such as Manipulation (co-opt and influence) and compromise. Data collected for this study did not go into great detail regarding these responses, however, some examples of actions are illustrated below.

There is evidence that PTEC-UFRJ's response to the challenges mentioned above has gone beyond Acquiescence in some points. Co-opting and Influencing tactics (Oliver, 1991) have been observed, displaying active concern and engagement with non-market pressures (Baron, 1995). For instance, Baron (1995) highlights that collective actions are valid strategies for responding to non-market institutional pressures related to regulations, which can commonly be organized through formal associations of firms. PTEC-UFRJ has remained an active member of the most important associations of innovation environments in Brazil, most notably ANPROTEC, ANPEI, and ReINC. All of these associations, among other things, have the mission of discussing, suggesting, and orienting the development of public regulations for the segment of Technology Parks and other innovation environments, they have indeed played major roles, for instance, in the development of the Brazilian Innovation Law of 2016. Oliver (1991) classifies participation in such associations as one mode of Manipulation strategies through Influence tactics, part of the most active response strategies, which Fleck (2010) advocates as necessary for dealing with non-market pressures over the long run. While mere membership on associations does not guarantee participation, PTEC-UFRJ's case provides enough evidence to validate its active participation in such associations. Its participation in discussions and development of policy was illustrated in its sustainability report for the year of 2015, which reported that "the park has actively participated in the creation of the [constitutional amendment] #85 of February 26, 2015" (p. 23). This amendment included the responsibility for promoting innovation and innovation environments, such as Technology Parks, as a constitutional obligation of the Brazilian government.

Co-opting tactics (Oliver, 1991) are reflected in the multiple committees composed with external representatives of stakeholders (of the university, government entities, companies, COPPETEC, and the park itself). These set of committees are discussing and deliberate on matters such as: the value each project has to the university, from UFRJ's perspective; appointment of General Directors; approval of new resident companies; validation of architectural standards for constructions to be made by new residents; and more. Actors present in these committees include representatives of Rio de Janeiro's prefecture; representatives of the diverse academic departments in UFRJ, and the dean; representatives of important partners such as CENPES (Petrobras), SEBRAE, FIRJAN, FIRJAN, among other; a representative of

resident companies; and more. In addition to co-opting via committees, PTEC-UFRJ also has the ability to have public servants tied to UFRJ as employees, which has happened to some extent during its life, even to the extent that the position of General Direction can only be held by individuals tied to UFRJ as public servants. Finally, co-opting can also be observed as a by-product of PTEC-UFRJ's partnerships with UFRJ that go beyond R&D projects for technological innovation: In this subsection, we have illustrated diverse ways in which PTEC-UFRJ interacts with and generates value to UFRJ, in addition to encouraging companies to go beyond R&D projects, by validating a wider set of initiatives as part of their contractual obligations, and also actively proposing such "non-obvious interactions". This last dimension sits well within Oliver's (1991) description of Co-opting by "use of institutional ties to demonstrate the organization's worthiness and acceptability to other external constituents" (p. 158). The structured, systematic, performance of these activities is evidenced by the creation of the teams for "*Internal and External Communications*" and "*Institutional Development*".

Regarding regulations within the university, discussions have been on-going since 2019 for UFRJ's new Innovation Policy, including diverse stakeholders in the university. PTEC-UFRJ has indeed been an active participant of such discussions, therefore representing their interests and demands, instead of passively waiting without any involvement.

Table 12 summarizes PTEC-UFRJ's responses to institutional pressures, discussed above, in light of the tactics proposed by Oliver (1991):

Table 12 – Responses to institutional pressures

Compliance	with strict regulations
Balancing	projects with diverse areas of the university, reaching beyond Technological R&D&I and articulations with companies.
Co-opting	public servants linked to the university (even mandatory for General Direction); multiple committees integrating the park, companies, the university, and representatives of multiple public entities;
Influencing	active participation in associations (Anprotec, Anpei, ReINC); active participation in internal discussions for UFRJ's policies;

Source: created by the author

The next dimension of the environment is that of Activities, that is, pressures mostly associated to the market and the competitive environment. In regard to competition from other Technology Parks, it seems PTEC-UFRJ has not dealt with much pressure throughout its existence as of yet. The interviewee below explained this in terms of “territorial respect”:

[...] of course, there is always some level of competition, but I would tell you that, I mean, as they are regional projects, it is really difficult that a park would get out of Rio de Janeiro to approach the market in Recife, you know? For example, because in Recife there is Porto Digital, which is super strong. We are not going to move from here to São José dos Campos, because there is the São José dos Campos Park. So I think there is a territorial respect [...] (Interviewee D)

Although such territorial movements have been observed to a low degree, the interviewee above stresses that the relationship between Technology Parks has been much more one of cooperation than competition:

[...] but there are cases of that. For example, I know that Porto Digital, for example, has some operations in São Paulo, but that is it, São Paulo is [huge], São Paulo's market is very developed. São José dos Campos, for example, is consulting for a Technology Park that is to be implemented in Maricá, well, Maricá is Rio de Janeiro. So, I mean, there isn't so much of a thing such as “oh, in Rio de Janeiro only UFRJ's Technology Park can do things”, there is no such a thing. But I think that, at least from what I see, I don't see so many cases of disputes and all. So, I would tell you there is more cooperation than competition between the parks [...] (Interviewee D)

This perception of low to non-existent competition between Technology Parks, instead being a relationship of cooperation, was shared among other interviewees:

[...] when I arrived at the park, I had much difficulty to understand that it was an environment for the greater good (*ambiente do bem*), you know? When we work for a company, companies have competitors, right? Direct. Innovation is a world where you want to share knowledge. So, I don't know, with Porto Digital in Recife, with Tecnopuc. We did many things to exchange experiences with other innovation environments too, there were many events, many things like that. [...] (Interviewee C)

Anecdotally, even when events outside PTEC-UFRJ's control led to a situation where it was directly competing with another park, there were no active attempts to swerve the outcome:

[...] I will give you an example: there was a company, which is Dell... I mean, yeah, a company called EMC, a data storage, big data, company, which was bought by Dell. And at Tecnopuc, Porto Alegre, Dell had a research center in there, and we had an EMC research center in here. Then, EMC became Dell EMC, in other words, the same company had two research centres, one in Tecnopuc – a Technology Park in the south, Porto Alegre –, and another one here. So, the company had to make a decision, and they decided, by chance, to stay here in our park. But it was not a dispute, you see it? We were happy

to win the decision, but there is no Lobbying, see? That is it. [...] (Interviewee D)

When considering territorial boundaries, as suggested by Interviewee D above, the possibility of any competition potentially arising between parks was indeed low in the Rio de Janeiro region. During the entire existence of PTEC-UFRJ, there were only two other parks operating in the region, BioRio (now incorporated by PTEC-UFRJ) and Serratec (an ICT focused government initiative of three cities in the state of Rio de Janeiro). With such small number of parks, even if the relationship between parks were less of cooperation and more of competition, there would not be many pressures on PTEC-UFRJ in this regard (this situation may gradually change in the near future as plans for at least seven other Technology Parks in the Rio de Janeiro state have been announced).

Another dimension of competition could in theory happen inside the university itself. As mentioned before, UFRJ has a number of actors participating into its innovation ecosystem, and this ecosystem has a decentralized nature. The main actors, besides PTEC-UFRJ, include: COPPE's business incubator and COPPE's co-op incubator; the Innovation Agency; 16 Junior Companies from diverse areas; an Embrapii unit attached to COPPE; COPPE in itself, through the COPPETEC foundation; in addition to the individual efforts conducted by research groups and individual researchers. Also as mentioned before, the decentralized nature of this environment was observed to, at times, produce intersections in terms of which activities are performed by whom. However, data from our interviews, when mentioned, suggest the relationship between the actors in UFRJ's ecosystem is not looked upon as competition:

[...] I cannot see competitors, I cannot. Look, in the innovation process, and when we believe in open innovation as something that is more efficient for building a society that is effectively just, you don't... Especially inside UFRJ, ok? [...] (Interviewee I)

In reality, even if the ecosystem is decentralized and at times superposition of some activities may occur, in general, every actor inside UFRJ's university ecosystem has different capabilities, supplementing each other. For instance, anything related to Intellectual Property is handled by the Innovation Agency, so anytime a company at the Technology Park, or the business incubator, or anywhere else need support in

interactions with the university that relate to Intellectual Property, the Innovation Agency is called upon:

[...] I think that in some agendas [the division] is very clear, as in the matter of Intellectual Property. We [the park] do not get involved, every time a project with a company touches the subject of Intellectual Property, we invite the agency to observe and orient. [...] (Interviewee A)

Naturally, the Technology Park also has capabilities not present in other actors of the ecosystem, which help complementing the greater picture, the most obvious difference being the capability to host large companies within its area.

[...] all initiatives, even if parallel, some will be more efficient in some respects or more efficient in another. And they will help, one another, to answer the diverse demands the ecosystem gets. So, for example, there is the business incubator, which delivers a series of services inside a framework for companies that apply to enter, and there is a process there. This does not compete with the park, this is very cool because you are building a whole. [...] (Interviewee I)

Our data suggests therefore that competitive pressures, in the case of PTEC-UFRJ, have remained low throughout its existence, both in the macro dimension (in the relations with other Technology Parks) and the micro dimension (in the relations with other actors of UFRJ's innovation ecosystem). It is possible to theorize that other types of actors in the market may indirectly compete with the park, such as coworking spaces with business services, venture capital and venture builders, startup studios, business consulting companies, technology transfer consulting companies, etc. However, none of these were brought up during interviews. Consideration for such types of external entities may have been attenuated for PTEC-UFRJ, as it has strongly established its scope to be focused on harnessing UFRJ's capabilities. While there are examples of Technology Parks in Brazil that operate with the purpose of articulating interactions with multiple universities and research institutes (examples include the São José dos Campos Technology Park and Serratec), PTEC-UFRJ has decided to remain within the scope of UFRJ.

[...] what is very clear to me is that I have this thing about UFRJ's ecosystem. Now, I would have no problems to do this also alongside people from UFF [Federal Fluminense University], but look, whoever is going to connect me with UFF is very likely some UFRJ researcher who is co-authoring with a college from UFF. Because otherwise I would end up losing the characteristic which I think is what distinguishes me: I, today, am a UFRJ initiative, my institutional form today places me inside UFRJ.

If in some I-don't-know-how-many years from now the park becomes a UFRJ spinoff, if that becomes the institutional form that better serves the

development of society, etc, etc, etc, and this gives the park another institutional shape, that is a different story [...] (Interviewee I)

For its containment within the boundaries of harnessing UFRJ's research and knowledge, specifically, the relevance of other external players that support innovative companies was diminished. This scope was clearly indicated in 2013 as the park changed its name from "Rio's Technology Park" to "UFRJ's Technology Park".

One of the necessary qualities needed for overcoming the challenge of navigating into the environment is the ability to properly scan the environment, to enable an organization to identify threats and opportunities arising thereout. Data is sufficient to suggest that PTEC-UFRJ has not neglected the necessity to scan its environment. PTEC-UFRJ has been part of associations for Technology Parks and/or innovation environments in general at all levels. Regionally, the park is part of ReINC, the Network of Agents for the Promotion of Innovative Enterprises in the State of Rio de Janeiro. Nationally, the park is a member of Anprotec, the National Association of Entities for the Promotion of Innovative Enterprises, and globally, it is a member of IASP, the International Association of Science Parks. In fact, Maurício Guedes has presided both Anprotec and IASP in the past. His tenure at Anprotec was prior to PTEC-UFRJ coming to life, and Maurício himself played a role in the efforts that ultimately led to the creation of Anprotec itself, in the late 1980s. His tenure at IASP was in the early to mid 2010s, concomitant with his role as General Director of the park. The park is active in the network created by these associations:

[...] we participate annually in the conferences, particularly, I always participate. In Brazil some other people from here participate, and, in general, when it is abroad, I represent the park [...] (Interviewee D)

The main role of such associations is precisely to create a network of innovation environments and establish communication channels between them. All associations promote events in which information regarding experiences, projects, standards, trends, and other relevant information can be exchanged among innovation environments. For example, presentations of research papers relevant to the area is performed, prizes for new "best practices" are delivered, and general information regarding the subject of innovation, technology transfer, etc, are discussed:

[...] In these events, there always are presentations of [research] papers. We ourselves, if I'm not mistaken, hosted a conference here in Rio, two years ago, we were the organizers. And in last year's congress, we presented papers about our cooperation system [...]. Anyways, the answer is "yes, yes and yes",

it is very important to be aligned with what is being done in the field [...]
(Interviewee D)

Participation in these associations was the only systematic/structured way in which PTEC-UFRJ collected data regarding developments in other Technology Parks, as far as interview data shows. However, more has been done in this area by establishing personal connections with personnel that work and manage other Technology Parks in the country. Some of these personal connections were facilitated by encounters that happened due to those associations. The quote below describes the informal/relational process of interacting with other Technology Parks for observing trends:

[...] In reality, I mean, there is no [formal] interaction. We used to meet a lot because of Anprotec, which attempts to make this work. But I thought that... This is how it went: "look, there isn't anything formal, I think I will have to just go there and have a face to face conversation". I stayed for two days, we exchanged information. And this was interesting, I believe that I learned a lot, we exchanged much information, tried to support each other. Because I think the individual [side] is everything. It doesn't matter... you know, there is no institution that is going to make you [do this]... Personal relationships are everything, I work much that way. And so I opened channels to various people: Lessons learned, I would come back and we attempted to fit [the newly learned things into PTEC-UFRJ]. Something of an explorer, I went there, did it, and thought it should work [...] (Interviewee G)

Overall, scanning for information regarding the operations of different technology parks, nationally and globally, is present and stronger in the form of personal relations (informal social interactions):

[...] At the São José dos Campos [Technology Park], for instance, Rodrigo Mendes, which is the guy who takes care of their international [relations], is a work friend that I gained through the movement. We always talk now; we are always exchanging information about the operation of the parks. Therefore, there is an interesting community in Brazil, and also an international [...] (interviewee D)

Not much additional data regarding activities to scan the environment could be observed. Some interviewees emphasised that harnessing information about other Technology Parks, for learning and improving, do not have a better alternative than simply establishing social connections in the form mentioned above. The associations, in addition to creating channels for communication that ease the creation of this network, also release research reports, articles, and general information regarding Technology Parks, Incubators, legislation, and other relevant topics for the area of innovation. Another mechanism worth mentioning is the existence of committees formed by multiple stakeholders, the park, the university, resident companies, and the

government. One example is a committee that is responsible for judging whether or not a cooperation project is on the interest of the university, and to value how much a project is worth for the university (as opposed to market values, in order to fulfil the contractual cooperation clause). Due to the presence of multiple stakeholders, these committees can therefore ease the process of collecting information that should be taken into consideration for decision making, and might be seen as a way of co-opting tactics mentioned by Oliver (1991).

6.3 Human Resources

Responses to the challenge of Human Resources provisioning have been mixed. The majority of Human Resources hired by the park fill-in positions related to facilities maintenance, with a relatively small amount of managerial and entrepreneurial resources engaged in the core business of articulations. While retaining personnel related to the facilities area has been very high, the park did display difficulties regarding the second area. Because some personnel have been hired to fill-in key roles under the condition of scholarship holders as graduate students, the relationships therein established have been timed from the beginning. In addition, it was reported that difficulties in continuing these relationships have their roots in budget constraints and, more importantly, in the small hierarchy existent at the park, leaving little to no room in terms of upwards growth. However, we observed that both current and ex-employees have a very positive view of their time at the park, using words such as “family” and “passion” to describe it, which suggest that the potential to retain these human resources likely exists, despite the limitations mentioned before.

As for the selection & recruitment, renovation, and succession of Human Resources, we didn't observe systematic procedures set in place. Some of the hiring for managerial positions have emerged from relational links made prior to the need, although not planned in advance before the necessity arose. Examples include the acquisition of personnel from COPPE's incubator, students from UFRJ indicated by UFRJ professors, and qualified people that were known by someone at the park. The data suggests an overall tendency for just-in-time acquisition of managerial resources, although not all hires fall into this category.

Table 13 – PTEC-UFRJ's responses to Human Resources challenges

Dimension	Organizational behaviour
Selection & Recruitment	Hires for management positions have occurred through links that existed prior to the necessity (e.g., from the business incubator, from indications, from researchers who studied the park, from professionals who previously delivered outsourced services). Selection of General Director is more systematic through a dedicated committee.
Training and development	The park was observed to provide and encourage training for its human resources; Managerial personnel have taken part into training courses for management of innovation environments offered by external institutions and UFRJ itself; Operational (facilities) staff have also received support for education, such as partial financing of school fees;
Renovation	We could not observe systematic procedures to anticipate Human Resources needs; The park is partly affected by limitations related to personnel hired under scholarship grants. In general, the park has tended towards just-in-time provision of resources;
Retention	Retention for some key positions was affected due to hiring personnel under scholarship grants; Interviews suggested that it was natural to expect highly skilled personnel who are not in chief positions of an area to leave the park at some point, due to the small array of positions available at the park for hierarchical growth; Retention for the lower levels of the hierarchy (real estate maintenance) has been strong.
Succession	We could not observe systematic procedures for succession, apart from the position of General Director (pooled from the university, with a specific committee of stakeholders for its approval);

Source: created by the author

The challenge related to the provision of Human Resources is essential in light of Penrose's (1959) theory of the growth of the firm, provided that managerial human resources, or the lack thereof, directly set the upper boundaries for growth that an

organization may be able to undertake. The availability of services rendered by managerial human resources is not only linked to the quantity of personnel, but also to the experience acquired by this personnel within the organization while working as a team, implying that just-in-time acquisition of these resources may not be sufficient to render adequate services to the organization (Fleck, 2009; Penrose, 1959). Managerial Human Resources may be fully engaged in enterprising activities for growth, or used up for managing the existing scope of operations projects, the amount of Human Resources available to engage in growth-seeking activities therefore comprises an important dimension of slack generation for the organization. More broadly, provision of Human Resources in General, not just managerial, naturally also plays a key role in enabling the organization to fully take advantage of available opportunities.

The matter of Human Resources at PTEC-UFRJ was brought up during most interviews. Overall, as will be exposed below, some interviewees have described the availability of Human Resources as less than ideal, at least part of the time, indicating a possible lack of proper slack generation in this regard. However, this view was challenged by other interviewees. This and other aspects of Human Resources at PTEC-UFRJ will be described below, as gathered from interviews.

In its sustainability report for the year of 2018, PTEC-UFRJ had 61 names listed under its team, 34 of which were allocated under the Operations Division, which concentrates the personnel responsible for maintenance, cleaning, reception, and other facilities services. As mentioned in the Enterprising section, PTEC-UFRJ, still during the beginning of its growth phase, decided to not outsource such activities, a decision which was viewed as a way to aid in keeping fast response times and high quality operations for its real-estate upkeeping activities, understood as somewhat of a second part of the park's core business, in addition to articulation activities. Interviews suggest that this decision may have been a point of divergent opinions within the park earlier on, with some advocating for outsourcing such activities, but later these discussions seem to have been settled in favour of not going through the outsourcing route.

[...] I am against [outsourcing]. There are some things that you can outsource, but one of the concepts that I managed to convince Maurício [Guedes] about was that... And, by the way, everyone would approach Maurício and say: "oh no, you've got to outsource everything".

No! Outsourcing is something that may be utilized by private companies which get some fiscal and financial advantages by outsourcing. But in the case of the park, my understanding was the following: the base team, the team which takes care of the cleaning, of serving breakfast, of maintenance, of reception [...], got to be people who belong to the park's team. With that, you establish a bond, you establish intimacy with those people, and you provide services that can really... at least it is [the assumption] I work with, what I believe in... you create commitment. And, when you outsource, commitment is really difficult, because the outsourced company, at any moment, changes the people who are allocated there, today it is someone, tomorrow it is someone else. And you don't get loyalty from such team. [...] (Interviewee B)

As for the “commitment” to be gained from the internal team, as opposed to unengaged outsourced personnel, interviews suggest that this was indeed the case, nothing that the staff turnover, among the operations team, has remained very low throughout the decade

[...] [turnover was] really small, really small. I think that [in] around eight years, [we] changed some two or three people. And even at that, sometimes it was because it was too serious so there was no other way, or because that person wanted out, wanted to go for another [professional] area or something like that [...] (Interviewee B)

In comparison to other teams working at the park, such as the one responsible for strategic planning and the one responsible for articulation activities, the facilities team is therefore considerably large, while other areas of the park were reported to work under “lean” teams:

[...] [The articulations team] had to work with lean teams, while some other teams, for instance the park's operations team, which takes care of all of the... As that area is a Federal area, the municipal government doesn't provide any services inside the park. So all of the public illumination services, road maintenance, garbage collection, all of that is made by the park's team... security... so there is a part of the park's team which performs security, maintenance, IT and networking operations, electricity, water and sewage operations, everything like that is made by the park itself. So the operations team, for instance, is a huge team that has 50 – I don't know –, forty and something, people. And the articulations team had three. So we've got some teams which are really big, and because they are at the outermost part of operations, they had to, necessarily, be big.

And at that point there is a series of questions, I'd rather not enter into these details and these intrigues, because there is a series of complex matters amidst it. We had some teams with that profile, but not [the] Articulations [team], even though [they] are at the frontline of company relations, [they] had a very lean [operation] [...] (Interviewee K)

As mentioned during the Enterprising challenge, in 2019, PTEC-UFRJ elaborated a comparison of costs between their internalized facilities team equivalent costs for outsourcing such activities based on publicly available contracts for similar cases (public institutions), and concluded that it was around 25% cheaper for these

operations to indeed remain internal, instead of outsourced, as a way to validate their decision in face of stakeholders. The quote above suggests that the rationale for keeping these activities internalized is straightforward and well understood, but nevertheless other important teams, such as the Articulations team, may be seen as “lean” in comparison.

The quote below explicitly states that there was a need for more people to be working at the park, and suggests that this view is shared by some ex-colleagues who also worked at the park:

[...] At moments, even talking to colleagues and reflecting upon what we have accomplished... The park was too much work for too little “arms” [people], I think it was a job moved by passion, you know? I am, personally, completely passionate about this area... [...] (Interviewee K)

In contrast the two interviewees below stated that there is no urgent need for more Human Resources at the park, two of the reasons being a) highly qualified personnel and b) a current movement into the direction of technological growth into the online world:

[...] I think that, today, we have an adequate team to do more than what we [currently] do, ok? I don't see that problem, again. Why? Because the people [at the park] are highly capacitated, that is the truth [...]

Also, for a philosophical reason, I remind you that the park is not “to do”, it is “to make do”, it is “to make [things] happen”. [...] We try to bring people together so that they talk. And, to do that, we still do not need much more people, even more so since our next challenge is to perform this in a more technologically advanced form [...] (Interviewee I)

[...] I believe we do have team slack for growth [...] (Interviewee A)

Nevertheless, Interviewee K, which did state a need for an expanded team, went on to add that small availability of Human Resources might be a shared reality among Technology Parks and other innovation environments in Brazil, in a general sense (supported by this interviewee's experiences in multiple innovation environments throughout the country):

[...] I think this is the reality not only of the park [PTEC-UFRJ], but of all innovation environments. Where you have very small teams, you don't get specialized labour to work in these environments, generally, budget is tight, [and] parks and incubators work with scholarship holders, which are temporary [...] (interviewee K)

The quote above identifies several sources of limitations to the availability and expansion of Human Resources for Technology Parks that are related to the

environment and the internal workings of the organizations. The first point, that of specialized labour, seems to characterize a challenging environment for acquisition of Human Resources, at least from the point of view of the park:

[...] for sure, it would be fundamental to possess a bigger team. We had difficulties in finding people with the [right] profile, and I think this was a challenge even after I left, so much so that some programs which I managed ended up being discontinued. Because it is hard, really, there aren't professionals on the market with such a profile. And there is the matter of demand, right? Because it is really intense [...] (Interviewee K)

This was attributed to an apparent lack of formal education being offered for professionals to work on innovation related areas, specially those regarded with articulating universities/research institutions to private companies and other stakeholders:

[...] you get labour which, generally, is not specialized. And this knowledge is not an objective knowledge, it is not a [type of] knowledge that is taught on traditional academic chairs [...] (Interviewee K)

Secondly, as mentioned during the Challenge of Enterprising section, a tight budget has been observed to be somewhat present throughout the existence of the park, also being mentioned as one limiting factor for Human Resources acquisition:

[...] for sure, if we wanted to [deliver] work that could reach the demands, at the level of demand posed by the companies, we would need a much bigger team. But there was a big budget restriction, right? The park [was] not profitable [...] (Interviewee K)

Finally, the third point mentioned by this interviewee as generally present in innovation environments throughout the country is related to the high utilization of scholarship holders. Which may pose both positive and negative aspects to it. For PTEC-UFRJ, positive sides of it have been materialized, for instance, in contributing to a greater integration between the Technology Park and internal stakeholders of the university itself, mainly students:

[...] I am really sensible to the matter of inserting UFRJ students into what the park does, so we always give preference, naturally, to UFRJ students [...] (interviewee D)

This provides another gateway to link the university, and knowledge acquired within, to the Technology Park. As well as contributing to generation of knowledge, and analyses, regarding the park itself: for instance, three of the interviewees who integrate this research have elaborated their Master's or PhD thesis/dissertations with studies about PTEC-UFRJ, while working at the park through granted scholarships.

Additionally, scholarships may be granted by public entities such as FINEP or the university itself, alleviating the challenges related to budget restrictions:

[...] Usually, innovation environments pay these people with scholarships, many times there are FAPERJ scholarships, FINEP scholarships...there are government scholarships or scholarships from the university itself, which pay for these teams [...] (Interviewee K)

However, somewhat negative aspects can manifest due to the temporary nature of these scholarship grants. If, for some reason, the park is not able to hire these people after the expiration of scholarships, retention of knowledge (learning), and continuity of projects/activities may be threatened:

[...] these scholarships are temporary, so you cannot retain this labour. Many times you already do not possess the knowledge, you pay this person relatively badly, you take one year to train this person, and then the scholarship ends, you lose her and swap her for someone else [...] (Interviewee K)

Based on Penrose's (1959) propositions, developing managerial and entrepreneurial services through experience time working as a team inside the same organization is essential to develop the necessary capabilities for undertaking growth, limitations on retention of personnel precludes this continuous development needed for increasing the pool of slack entrepreneurial and managerial services that can push an organization towards growth. The matter of scholarship holders, and graduate students hired as interns in general, is specially significant for the park since these people have actually taken responsibility for, and further improved and created, key activities of PTEC-UFRJ, as opposed to being mere interns with non-essential support responsibilities. For instance, the post-incubation program has been set in place and mainly carried out by one PhD scholarship holder, which also held a central role in carrying out the CrowdRio program during its two years of existence within the park. As another example, the interviewee below pointed out that, despite being an "intern" (Master's student with a scholarship), he did carry important responsibilities at the park:

[...] I was an intern, but I formally performed project leadership things, but that was because there was no one else to do it [...] (Interviewee F)

The Technology Park has been acting as development grounds for these scholarship holders and interns, which eventually became attractive for other innovation related organizations:

[...] The team is very stable. We have a staff turnover which I think is low. [Corporate Articulations] area, in particular, is an area where we develop

people, in general they remain there for three or four years, and then ascend. [...]

In general, [Corporate Articulations] works a lot with students from the university, grad students, Master's or PhD finishing their education. We've got there a development ground for those professionals, and opportunities arise. So, for instance, there was a girl that worked with [us], she remained for some four or five years at the park, she was getting a PhD, and then an opportunity arose at a venture capital fund for her, which was a marvellous opportunity [...] (Interviewee A)

When commenting on the possibility of contracting these people as effective employees of the park after scholarships are over, Interviewee K noted that it may happen, and such proposals have indeed happened, "but you've got these budget restrictions that do not allow for very big teams". In addition to budget limitations, PTEC-UFRJ may have simply lacked opportunities for personal professional growth due to its size:

[...] At the park, in reality, for a professional with some ambition, we have got little growth opportunities. The pyramid has few levels, it is squashed, isn't it? So it is hard for us to promise many a future expectations for a person that has ambitions, obviously, right? [...] (Interviewee A)

Indeed the matter of lacking room for continued professional growth within the park has been cited by multiple other interviewees as an important factor contributing to the challenges faced by the park in retaining these Human Resources (not quoted here as to not disclose personal information of the interviewees).

In addition to the effects related to Penrose's (1959) proposition regarding the necessity of team building experience to develop entrepreneurial and managerial resources, rotation of personnel involved in key areas the Technology Park may have had even stronger effects due to the tacit nature of much of the knowledge involved in articulating resident companies and the university. For instance, the interviewee below cited efforts made to codify knowledge related to one specific program of the park before leaving the park:

[...] **much of this knowledge is complex and hard to be transferred.** What I tried to do was to register all of it [...], or a good amount of it, and share. [...] We did not create systems because I am no [software] developer, but I created a series of spreadsheets that would, for example, automatically generate reports. [...]

I tried, within the limits of my knowledge, to automate and systematize this to the maximum. But if that will remain in use, if that will be adopted, if that will be utilized, is too complex to predict because **it has much of this thing about specific knowledge mixed in... in reality, many things get lost with these changes [of personnel]** [...] (Interviewee K)

At least part of this lost knowledge is “relational”, it has arisen out of personal relations to managers/entrepreneurs of resident companies, due to the close proximity that has been built between these and some of the park’s personnel.

[...] there is much tacit knowledge, and there is much knowledge that is also relational, you understand? As I said, I held meetings with [company] for one year and a half, one year to one year and a half, every week. I knew about the day in which the father of one of the partners got sick and how this had affected the contract they had to deliver; you know? It was a very relational matter. Maybe this even reflected on... as I told you, some companies were so close that when I left, they left [the park] too. [...] (Interviewee K)

This statement crystalizes the increased importance of Human Resources to the Technology Park, as it is realistically impossible to find professionals in the job market that carry such tacit and relational knowledge specific about the park’s resident companies and their journey at the park, since such knowledge can only be acquired within the park. As opposed to organizations whose core business is much more based on more technical knowledge that can be acquired prior to the hire. Especially considering that PTEC-UFRJ has, in the past few years, been engaging in articulations through both “pull” and “push” relations to its resident companies:

[...] more recently, closer to the period [of 2018], we also tried out different ways of stimulating it. Because, in a way, the demand was much more passive. We waited. And so we tried to stimulate it in other ways, being a little bit more active. So, offering, **understanding more these companies that were already installed there**, and how [they] could put it to practice, to, in fact, adopt an open innovation philosophy [...] (Interviewee E)

In light of the archetypes of responding to the challenges of growth (Fleck, 2009), there are three idealistic modes within the challenge of provisioning Human Resources, anticipated, just-in-time, and delayed. The better suiting response to this challenge sits at anticipated provisioning of resources, provided that just-in-time responses may lack the proper development of experience regarding the organization itself and the specific teams. The somewhat common utilization of Human Resources allocated in managerial and enterprising positions at PTEC-UFRJ under the aforementioned conditions, could be observed to have some negative impact on the response for this challenge:

[...] when I left, the person who would take my place had not [been hired] yet, much due to me having to leave before they could be able to get another person [...] (Interviewee K)

This suggests that, under the conditions upon which some personnel, who perform key roles at PTEC-UFRJ, are contracted, the park, just-in-time and/or delayed responses may have been imposed to the park.

Two examples of such just-in-time acquisition of resources, related to this type of workforce, happened at the end of 2018. A scholarship holder responsible for carrying out SMEs-related projects, such as CrowdRio and the post-incubation program, left the park. At the occasion, PTEC-UFRJ contracted a new person to fulfil the role, just-in-time. Shortly after, another scholarship holder, which was focused on the large resident companies, also left the park, and the newly acquired collaborator for SMEs was moved to taking care of large companies' projects. At this point, PTEC-UFRJ drew a person from COPPE's Incubator to take care of SMEs, to hold both the position at the park and at the incubator at the same time. This arrangement was short lived, having the manager returned to full time dedication to the business Incubator, and resulting in the park hiring a new person from the external job market.

Nevertheless, PTEC-UFRJ, incorporating its Hybrid organizational model (as per the Triple Helix), despite being under a public federal university, is not limited to working with public servants, interns, grad school scholarship holders, and outsourced personnel through the public management laws. It can, and does, hire employees as per "standard" Brazilian labour laws (CLT) similarly to what private companies do:

[...] at the park, we've got UFRJ [public] servants, a few. Today we only have two servants, which is the Director – it is mandatory that the Director of the park be a servant –, and the Architecture projects' manager is also a servant. They are the only two [public] servants. All the rest are hired employees, they are people hired through COPPETEC foundation. [...] So we have got [public] servants, CLT professionals, we've got scholarship holders, which, generally, is this: someone who is undertaking a Master's or PhD, and in general that guy is a scholarship holder because, in general, he is developing some research, too. And we have got interns, the difference between the scholarship holder and the intern is that an internship is [an actual] job. [...] (Interviewee D)

Therefore, limitations related to scholarship grants by itself, does not overwhelm the ability for the park to acquire Human Resources. In addition, the most inflexible form of work force, public servants, is reduced.

The position of General Director has its own singular set of rules, with a temporary tenure of four years (starting in 2015), a mandatory public servant relationship to UFRJ, and indication/acceptance by a committee comprised of several internal and external stakeholders of the park. Penrose makes a clear distinction,

however, when debating just-in-time acquisition of external Human Resources of “chief executive” roles:

[...] The emphasis I am placing on managerial experience within a firm does not imply that ‘outside’ experience is not also very valuable, especially for the ‘chief executive’ of a large corporation. It should be remembered that the ‘management group’ that we are discussing includes the entire managerial organization, subordinates as well as ‘chiefs’. Herrymon Maurer, in his breezy and journalistic, but frequently shrewd discussion of the ‘big corporation’, points out that decisions in the modern corporation are ‘group’ decisions in which the president, or chief executive, of the corporation may take little direct part; his role being that of providing relatively unobtrusive guidance, lubrication, and conciliation. It is incidentally for this reason that, while the management group as a whole must be experienced in working together, a new ‘leader’ from outside with the required personal qualifications and general experience, may very effectively preside over and ‘lead’ the ‘team’ [...] (Herrymon Maurer, 1955 apud Penrose, 1959, p. 42, footnote)

As for “standard” (CLT) managerial resources, analysis of the first decade of the park’s life suggested mixed responses. As a first example, in 2018, the park lost its head manager of Operations, in which occasion the park was successful in leveraging managerial resources already available within the park, to fill up this important position:

[...] at the Operations area, which is another very intensive area and where there are the most allocated human resources – which is to keep the infrastructure working –, we had a recent substitution. The manager left Brazil at that “Exodus” time, to Spain. And there was someone in the team, that used to coordinate an area, [who] rose to the management position, and is fulfilling it well, so I don’t see a crisis [...] (Interviewee A)

This same interviewee, regarding the availability of resources to fulfil her own management position, in case needed, also noted that it should be possible with current people at the park:

[...] I have been thinking about this for a while, and I do think so, I think there is a substitute person in my area. Of course, we never find a clone, but there is someone who can substitute me, yes. With advantages and, naturally, disadvantages, to my profile. But I think the park won’t stop if I needed to leave. [...] (Interviewee A)

Both these examples do suggest some level of anticipated provision of Human Resources. Furthermore, there were situations in which the park drew resources from COPPE’s Incubator, which, while formally separated from PTEC-UFRJ, do possess much synergy with it, shared resources, and an overall proximity of people and operations throughout their history. An example of this occurred for roles at the Corporate Articulations area. In November 2016, the head manager for Corporate Articulations left the park to assume a role at COPPE’s Embrapii unit, at the time, COPPE’s Incubator’s manager fulfilled the newly vacant role at PTEC-UFRJ,

remaining at the park and still engaging in some activities directly within the Incubator to this day.

Occasions, even recent, in which the park had to resort to acquiring external resources to fulfil newly vacant positions, seem to therefore indicate not much slack human resources to be available. It was noted that interviewees had opposing takes on the matter, such as “I think that, today, we have an adequate team to do more than what we [currently] do, ok? I don’t see that problem” (Interviewee I), contrasted with:

[...] Yes, for sure, it [the team] had to be bigger so that we could sufficiently respond to the companies. They, many times, complained that we took too much time to answer, or I couldn’t do it, since I was alone... to pay attention to the level of detail that they demanded. As I said, companies were very demanding. [...] Often, they wanted me to be there almost as an exclusive consultant, inside the company every day, helping and getting the job done. And we couldn’t handle that [...]. Also, during my time at the park, I was a scholarship holder, so my workload was 20 [weekly] hours... But alright, I did not stay there for 20 hours, right? I stayed there much longer than people who worked 40 hours. At the end of the day there was some overload, yes. [...] (Interviewee K)

[...] [My working hours] were mornings only, from 9 to 13, around that. But I stayed until 18 everyday [...] (Interviewee F)

As per both interviewees above (and a general consensus among all interviewees), it is worth noting that both pointed out having enjoyed their time spent at the park. Referring to the park as a “family” and the job as a “passion” was common among interviewees. Therefore, the mention of extra working hours is only meant as an indicator that suggests little availability of slack human resources under the light of the theoretical framework, not being related to quality of work life.

[...] because it was kind of like a family of people, it was a job but it was kind of a family. Dude, that park was something really special [...] (Interviewee F)

[...] I am really grateful for the time I worked at the park, it was a time during which I grew a lot, and which I had the opportunity and autonomy to develop things that I believe I wouldn’t have had in other environments. So I had much liberty, much autonomy, to propose new things, to design new things, and to operate new things. [...] and I loved it, I have always been passionate about my job. As I said, it is a job of love. And I developed a much big relationship to the companies that were there, so I felt responsible for the continuity of what had been constructed [...] (Interviewee K)

This last quote suggests that although there may have been a perceived need for a bigger team, enterprising activities – proposing, creating, and operating new things –, were still being carried out by the available team. Naturally, novel operations introduced to the park via this observed “autonomy to develop things”, partially

consumed the availability of enterprising resources, who became engaged in the operation of such new projects.

Finally, one interviewee mentioned an additional point regarding provision of Human Resources that is linked to the internal development of professionals, which may ultimately aid in producing potential new managerial and enterprising services withing the organization, to be available in anticipation of future need.

[...] In general, and it is even a philosophy established to this day at the park, which is: "let's make the progress of these people, let's work for the progress of these people". So, there, courses, [professional] formation, have always been incentivized. Some people who arrived to work at the civil area, maintenance area, and had not completed high school or primary school, we incentivized this person to study, to go back to studying, to do it. Meaning, at some point some courses have been subsidized by the park, but not 100%. I also believed people had to put in their part, for that to be valued. And many people took courses, including me. I took post-graduation, MBA in Project Management, at COPPE, inside the Polytechnic [School], through the park. In other words, we had some really big incentives for personal development of the team. I think it is super! [...] (Interviewee B)

Which indeed shows that PTEC-UFRJ has deliberately engaged in developing their already acquired Human Resources, further expanding services that can potentially be rendered by these resources inside the organization, which may or may not end up being entrepreneurial services, but may still nevertheless expand the pool of idle services that may ultimately be applied productively (Penrose, 1959).

In summary, PTEC-UFRJ has tended towards just-in-time acquisition of Human Resources for its management and core business (non-real estate services). This could be attributed to a number of factors: (a) highly skilled personnel, both in academic background and previous experiences; associated with (b) low availability and high demand for such personnel in the market (according to interview data); (c) a financial position not too strong to keep such highly demanded and skilled workers; (d) a "lean" hierarchy that leaves little room for professional growth (for those who do not occupy chief management positions); and (e) some key personnel joining in as temporary scholarship holders. The sole fact that PTEC-UFRJ demands such skilled labour and has manifested difficulties in finding these in the market indicates that just-in-time acquisition may be forced upon the park by its environment, as the park is not willing to compromise the quality of its labour force. In this sense, Human Resources at PTEC-UFRJ may be tied to Barney's (1991) Resource Based View. In fact, our data suggests that retention of Human Resources at the park is critical due to valuable tacit and

relational knowledge held by personnel, arising from their close interactions and observation of resident companies and the university over time, which (in the aggregate level) can be assumed to be virtually inexistent in the market. If this is true, then avoiding just-in-time acquisition of Human Resources can therefore be critical for the park's continued healthy existence, however more challenging.

As for Human Resources involved in support services and lower levels of the hierarchy (e.g., real estate maintenance), provision and retention has been adequately strong in the park.

6.4 Diversity

Provided that the park in itself is a considerably small organization, in terms of number of personnel and teams (areas/departments), initially, diversity may appear to be low, as internal resources may be highly homogeneous. However, the park is essentially a platform (a "hub", in the terms often utilized by interviewees), in which we should consider the different sides that the park works on connecting. As is explicit in the Triple Helix model, PTEC-UFRJ intersects private companies, a university, and the government. On the side of private companies, there is variety in terms of sizes, maturity and sectors. As evidenced by interviews, providing services for such varied set of companies requires different approaches. Furthermore, integration of resident companies among themselves is a point of interest. Interviews suggest that SMEs commonly display an interest in developing relationships with the larger ones, but this relationship does not follow automatically just from being located at the same park.

On the side the university, UFRJ specifically, variety is in the form of expertise in multiple knowledge areas, high number of laboratories and researchers, high research output, and multiple other internal actors related to innovation and university-industry interactions. All of this against the backdrop of differing opinions regarding the legitimacy of interactions with private companies. As an entity linked to a public institution in Brazil, PTEC-UFRJ is subject to the rules that regulate many aspects of its functioning in a stricter way than what is otherwise observed in private organizations. Despite belonging to the category of public institutions, the park has to intensively work with private institutions, as evidenced by interviews, this relationship may be impaired by a lack of mutual understanding if not worked properly. One

interesting result of being at the intersection of the Triple Helix is in terms of Human Resources with diverse institutional ties: in addition to the “standard” (private-like) job contract through COPPETEC, the park also receives a number of “employees” from academic backgrounds under scholarship grants (working on grad-level degrees), and public servants linked to the university. This contrast does hold potential for conflict. One although minor example at PTEC-UFRJ suggests that disagreements may arise when discrepancies between quality standards between the park and the university are clear.

Table 14 – PTEC-UFRJ’s diversity challenges

Dimension	Organizational behaviour
Heterogeneity	Heterogeneity is strong relative to the two sides the park has to match in order to deliver its core service of articulations: on the side of companies, diversity of sectors, maturity and sizes of resident companies, on the side of the university, great diversity in terms of laboratories, expertise in different academic areas, and research output. This, in addition to dealing with government entities, has demanded diversity in terms of Human Resources skills. The park needs to navigate the academic, the governmental, and the private enterprising worlds, which resulted in teams with a diverse set of competencies (e.g., many of which had extensive academic backgrounds plus industry experience, some of them were researchers themselves while working at the park, some of them were public servants linked to the university).
Mechanisms for cohesion and synergies	<p>The park has continuously put effort into integrating resident companies among themselves (an expectation manifested by SMEs). This has been challenging for the park to deliver, with success cases being attributed mostly to recent trends in the market that have popularized relationships between large companies and SMEs.</p> <p>Integrating resident companies with the park itself has been notably strong after the creation of the Program for SME Residents and the Post-Incubation Program. With large companies, the park has developed an active posture as opposed to passively waiting for requests.</p> <p>On the university side, the park has continuously engaged with multiple actors of the ecosystem to map out available knowledge, and to establish partnerships; There are committees set in place, which are composed of a variety of stakeholders, including the university and government representatives.</p> <p>The small amount of personnel and small hierarchy may have aided in keeping cohesion throughout its history. Teams have worked in close physical proximity and have personally known each other as a result. It has been suggested that integration across teams has weakened in terms of decision making and keeping track of tasks (described as “compartmentalized”). Recently, the park has set in place systematic procedures to stimulate frequent communication; as for personnel allocated in facilities maintenance, the park has decided not to go the outsourcing route, the rationale behind it was indeed to avoid distancing.</p>

Conflicts rivalries	and	No major confrontations and deviance into political arenas (Mintzberg, 1985) have been observed. On the contrary, some have even described the park as “family”.
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Source: created by the author

We will elaborate on the sources of diversity identified in the park, in terms of describing where the diversity originates, why is it relevant (what challenges or opportunities they brought to the park), and how the park has responded to them. These sources are split between internal and external diversity. The response will provide us with evidence to evaluate if PTEC-UFRJ has taken active stances to deal with the sources of diversity, and if it has applied strategies of exchange and sharing resources, as well as clues to evaluate whether it has tended towards fragmentation.

Internal diversity in the park was observed to be low over its existence, since it has kept a small hierarchical structure and number of employees (with a maximum number of concurrent employees below 60). The park operates a single campus, not being spread out geographically, and its main resources lie in the form of human resources skills (as opposed to machinery and technological infrastructure). The platform-like nature of the park, combined with its hybrid organizational type, places PTEC-UFRJ in a spot where external diversity has been much more relevant over the years than internal diversity. Diversity in terms of resident companies (sectors and sizes), the university (academic areas, number of researchers and laboratories), and government entities have been observed to be the main sources of variety. As these lie outside the organizational scope of the park, PTEC-UFRJ has little room for manipulating and integrating diversity in these areas (when compared to internal sources diversity), as the park has no formal authority over the organization of external actors.

Diversity of resident companies provide interesting grounds for discussion. Naturally, resident companies are clients of the park, in that they pay in exchange for articulations, real estate and business support services. It is common that integration and interactions among clients may not be a major concern to service providers in other types of markets. However, for PTEC-UFRJ, interactions among resident companies are a source of opportunities, so that these interactions are in the interest of the park. Mainly, integrating resident companies can be valuable for them, as they generate commercial opportunities and potential for innovation from joint projects. In

this sense, the opportunities for interacting with other companies at the park can be an additional reason for companies to join the park. Our data suggests that such interactions between resident companies was indeed manifested as an interest of resident companies, especially in the case of SMEs wanting to interact with large companies for commercial opportunities. As mentioned, we categorized resident companies as external sources of diversity, for they all constitute completely different organizations and management structures separated from the park, however, despite being external organizations, their relationship with the park is long-term, holds close physical proximity and continuous interactions. This close relationship does provide some room for PTEC-UFRJ to actively work on integrating resident companies, at least to some extent. And indeed, we have observed that PTEC-UFRJ has put some efforts in this area. Below, detailed description of this source of diversity will be provided, in addition to an account of PTEC-UFRJ's responses. After this, internal diversity will be discussed.

The first level of diversity in regard to resident companies comes in the form of the economic sectors these companies operate in. While there are Technology Parks that choose to focus on one or a few specific sectors, PTEC-UFRJ has been open to multiple sectors since the beginning. The criteria that guide which sectors are of interest to the park was defined through the academic areas where UFRJ is known to hold excellence, and these are many:

[...] We always believed that the park will express, the resident companies will express, what is the best in the university. If our model is to make the university-company connection because cooperation will increase competitiveness for our residents, we will have residents where the university is best, right? Where it is excellent. So oil & gas is [included], right? It is true, we have excellence in this area. Health and bio, let's name it Biosciences, Bioeconomy – I do not want to call it Biotec because that is too specific –, but there is a big package in the bio world where UFRJ has gigantic expertise, it's not a coincidence we see the university's expression in combating Corona[virus]... Covid[-19]. Beyond that, other areas of excellence: IT, which is obvious, right? I think everyone has to be excellent in IT, and many times IT is also serving other areas; Defence, - UFRJ has many initiatives in the Defence area. And Defence at times may be hybrid, something that has military applications can become civil, this is something; And the creative industry, which is another area that was identified in an analysis of the university has an excellence area. I think we have many things like Carnival, the communications school... And also the creative industry [has great diversity], we can add many things in it. It is an area that was pointed out; Oh, and there is another vertex which is sustainability, and then there is Energy, which can fit within [sustainability] or inside oil and gas – it could be Oil & Gas and Energy –, or we throw it inside sustainability, and then we can look at energy from other angles. [...] (Interviewee A)

Due to the opportunities generated by the pre-salt rush, there was an initial influx of companies concentrated in the oil & gas sector in the park, however, in no moment has the park changed its multi-sector strategy for one focused on the oil & gas industry:

[...] at that moment [2008 to 2012], the park got much imprinted with the presence of oil & gas sector, and we got known as the oil & gas park. It was coined the expression that it was the Silicon Valley of oil & gas, of energy. And, obviously, we would not turn our backs on such relevant prospects as Siemens, for instance, as Schlumberger, as Halliburton. But we always knew about the risks of [...] specialization. As time went by, we have seen what happened to the oil & gas industry, but we already knew that diversification was important, since always... we always knew that. And then a more concrete diversification agenda happened. [...] (Interviewee A)

With the 2014 crisis, market pressures pushed the park into being more active in realizing its multi-sectorial goal. And it has succeeded in attracting companies such as MJV (business consulting), AmBev (beverages), Senai CETIQT (textiles), Twist (IT), etc.

The second level of diversity in regard to resident companies comes in the form of different sizes and states of maturity. Until 2009, the park had the ability to receive mostly large companies, as potential residents would need to build a new facility from the ground up. Starting in 2009, Petrobras began gradually transferring spaces in the shared buildings, which became available to the park for housing SMEs. As our interviewees have observed, SMEs have much interest in interacting with large companies whenever possible:

[...] The expectation of the small company is always to sell. They wanted to have commercial partners, they wanted to sell to the large companies, or participate in joint R&D projects, [to be] service providers. [...] (Interviewee K)

However, such interactions proved difficult for the most part. Two major reasons for such difficulty were pointed out, the first is related to bureaucratic barriers that may render R&D managers of large companies unable to decide or influence commercial decisions of the company:

[...] what happens is this: [] the small companies were installed there as a whole, the entire company, the entire CNPJ, the entire team was at the park. The large companies were not, we did not [house their] operations. The large companies are installed in the park with just the R&D centre, so there is not a commercial area, there is not anyone who has the purchase decision power, to contract, within the park.

And often they are [at the park] to develop these projects with Petrobras, to develop projects with the university, and the demands, the strategic actions, are imposed by the international headquarters. So, what Schlumberger will develop is already defined in the strategic planning of Schlumberger

International, and they are [at the park] to perform R&D in this, this, and this area, and that is a closed deal. Now, if they are going to contract Promec, which is a micro or small company at the park, to do something? They do not have that vision, and they do not have that interest.

It is a matter, partly, of misalignment of visions and expectations.

We, for a long time, tried to make such [connections], and we stumbled upon some really big challenges. First, this interlocution issue: who buys, the supply areas, the purchase areas, the commercial areas, are not there. And for a small company to sell to a large company, it is very complex. To go through the process – specially in the oil & gas sector –, through the entire homologation process, and to be qualified as a supplier. This is very hard, very slow, and very costly, it is not a simple process. It is not like: “oh, I am here next to you so I am going to contract you real quick and we figure it out”. So this was a first big barrier. And, next, there was this alignment of strategic demands, right? The large company kind of already has... it kind of depends on what they would develop, and the small company did not fit well into that. [...] (Interviewee K)

Not only there was a larger distance between areas other than R&D departments of large companies and the park, and a hierarchical barrier for R&D managers to contract SMEs, but there was also a simple lack of understanding or preparedness of larger companies on dealing with startups:

[...] It was very difficult, right? What we realized was... It was even the director of [a resident company] who talked to me [...], he said: “[...] it is too complicated to work with Startups, so it is no use if you come here with a startup because I will not know how to operate it. They need to enter the chain; they need to enter a medium company that connects with a larger company with whom I already know how to work with” [...] (Interviewee G)

In addition, the challenge of integrating SMEs and large resident companies may have been accentuated due to specificities of the oil & gas sector, which makes up the major set of large resident companies:

[...] this is not very mature, you know? In Brazil specially, these interactions. Some parks are more evolved, in Brazil. UFRJ's park, I think, has some of this tradition of ours, [related to] the profile of companies located there, oil & gas. They are more traditional companies, so they do not have much of this experience, and, in a way, they have a little bit of apprehension, let's put it like that, to create relationships with small companies. [...] (Interviewee E)

Even though such difficulties were observed, the park did continue to put some effort into trying to promote such interactions, for instance, by doing events for its residents which were specifically aimed at integrating SMEs and large companies:

[...] what we tried to do: we made some workshops with the small companies, in these workshops the big companies would present their demands, and they would say: “look, our strategic development plan for this year is this, this, this, and that. We will develop Rizer technology, whatever else, Christmas trees, we are looking into such system...”. And the small companies would hear that,

and understand if, somehow, they could contribute. And we tried to facilitate this [connection] [...] (Interviewee K)

However, for the most part, such link between SMEs and large resident companies continued to prove difficult despite the park's efforts:

[...] But we realized that much of it did not go forward, many of these articulations ended up not evolving. Because there came a time in which, as much as the R&D manager could be interested in and found some idea to be nice, he did not have contracting power, he did not even have, often, tools for contracting that [small] company. So we had much difficulty with this [connection] [...] (Interviewee K)

Not only were such events not very effective into overcoming the bureaucratic and strategic barriers for interactions between SMEs and large companies, it was noted that even getting engagement of R&D managers of large companies to participate in events (focused on such types of interactions) was difficult:

[...] Many times, depending on the event, very few large companies showed up. [...] For example, usually engineers went there when we made thematic events [like] "let's discuss offshore petroleum exploration", the event would be crowded with engineers. But for "let's discuss about interactions between small and large companies", if just a single blessed individual showed up, it was a lot, you get it? Depending on the theme we had higher or lower engagement. [...] Especially when we held these events in which interest to participate was much more from the part of small companies than the large ones. They [the large companies], would at best get a lot of small companies testing their patience, when they already knew they would not be able to contract and that this was not very interest-generating. [...] (Interviewee K)

It was observed that the relationship between the park itself and other areas of the large resident companies – beyond their R&D facilities located at the park –, was not strong. PTEC-UFRJ demanded from all large residents one representative, allocated in their R&D centres at the park, and this served as the main formal channel for communications between PTEC-UFRJ and the residents. For example, when inviting large companies to join the events mentioned above, even the ones oriented towards commercial relations between SMEs and large companies, the invitation was made through this R&D representative:

[...] We did not deliver invitations like "oh, I want someone from the commercial area", we invited the company and sent the invitation to our interlocutors, which were the R&D directors or managers, and they distributed it to their team. [...] (Interviewee K)

An example of connections directly from the park with other areas of large companies, beyond R&D, was limited to a database of contact information that could be used in order to try and make an initial conversation between SMEs and the other areas of large companies:

[...] How do we try to mitigate this? We have, for example, contact with key areas of the company. So, for instance, we have here a list of HR managers and directors, we have a list of directors, we have a list of technical personnel. There is a facilities thing, of operating the buildings, for instance, because the park is also a real estate initiative, right? So we have a workgroup with the facilities [teams], the operation managers of these companies.

So we have access to these guys. So, when a small company, for example, needs to contact someone and is not able to do it, they can [call] us and we enter the circuit, and so that is it: we activate the contacts we have, to identify the best person to talk with that [SME]. So it is something like that, there is an artisanal quality to it, you know? To articulate in this sense demands something personalized [...] (Interviewee D)

It was however noted that over the last few years, integration between startups and SMEs with large companies had gradually been eased. But our interviews suggest that this was much more an organic change that happened to the market in general than related to PTEC-UFRJ's attempts in doing so:

[...] as years went by - this was [...] maybe 2017, 2018 -, we started to see a very big wave of open innovation programs, the relationship programs from large companies with startups. So, for example, one program that was a big success was Vallourec's program, Vallourec open, which opened the[ir] demands. They proposed challenges – not only to companies in the park, it was open to everyone –, [startups] could propose solutions for those challenges, and then, at the end of it, the best solution would be rewarded: they would get a prize and could even evolve into a POC [Proof of Concept] inside Vallourec. And we had many companies which managed to get into Vallourec, for example: Twist, GPE, which were post-incubation companies. Twist was one of the winners, I think, of Vallourec open. GPE participated in the process and ended up... due to the visibility they had during this prize, they managed to reach the commercial area in Belo Horizonte and closed a contract with Vallourec Belo Horizonte.

So, these programs, for example... I think AmBev also launched a program in this direction... These open innovation programs were a change of phase, in regard to the relations between small and large, not only for the park but also, I think, for the entire ecosystem. [...] (Interviewee K)

As is clear, this is related to a behavioural change of large resident companies, as opposed to an achievement made by the park. The interviewee below stressed this same point, and suggests that this movement towards open innovation may be a general trend in the market:

[...] I remember that at Natura, in a congress of theirs that I went to, they said they opened up some kind of a [department] just to deal with startups, because startups are something different. Not today. Today I think everyone knows it already, right? I mean, many companies are already investing in this, and today startups became the salvation for everyone, specially because of digitization. But, at the time, startups, those poor things, could not enter [large companies], and [large companies] did not know how to handle them. And we kept trying to insert them in the chain all the time, and that is how it was. We did not achieve much.

Now, naturally, this thing about innovation and agility... In the entire world, large companies began to realize startups were there. So then this started: the big ones went straight to the startups, they did not even want the middle companies anymore, the medium company. So, now, startups with large companies is what everyone wants for their lives, right? Everyone holds Hack-a-tons to catch some startups, it became such a trend.

Now, [from] our efforts inside the park, nothing happened. This is something natural that happened in the world. [...] (Interviewee G)

Naturally, the main goal of PTEC-UFRJ from the ground up was to promote interactions between companies and the university, in this way, integrating companies among themselves may be seen as a secondary role or out of scope on a first glance. However, such integration was also a way PTEC-UFRJ envisioned to increase the value offered to its residents, both the large and small ones. For small and medium residents, benefits are clear in the form of market development and commercial opportunities. As for large companies, it was pointed out that PTEC-UFRJ also wanted to offer “less obvious” interactions. These less obvious interactions were meant in two senses, the first is interactions with other academic areas that did not come naturally, at first, to the companies, and the second are exactly these interactions with other companies at the park. This was described as an effort for the articulations team to be less passive in waiting for demands, and instead also work to instigate new types of demands:

[...] More recently [...], we also tried to stimulate [interactions] in other ways. Because, in a way, demand was too passive: we [just] waited. Then we tried to stimulate them in a different way, being a little more active. [That is], offering, understanding more the companies which were already installed there: how they could practice, and, in fact, adopt an open innovation philosophy.

Because, now talking a bit about the concept of innovation, they went much more in the direction of what would be... it is not closed innovation, because they went beyond their walls, but it was a very small boundary they could reach. So we wanted them to not only have these interactions with the university - and now talking about interactions with the university [...] -, [we wanted] them to open up the horizon of opportunities, and these were non-obvious interactions, at times. [...] So we tried to offer beyond what would be those trivial interactions they could have, with other [university] departments, and also presenting opportunities for working with small companies, small and medium. [...] (Interviewee E)

In summary, grouping large companies and SMEs within a Technology Park posed opportunities for interactions between those, and these opportunities were observed by the park. Integrating companies in this sense was however not an easy feat at first: PTEC-UFRJ had frequent attempts in articulating such interactions, and

observed major challenges along the way. More recently, integration between these companies was observed to become easier due to trends in the market, where successful cases of SME x large company interactions at the park were achieved. These success cases, however, are majorly attributed to the natural changes in behaviour of the large companies, and much less to the efforts produced at the park. It is necessary to note that integration between resident companies is more in the direction of realizing opportunities than mitigating threats of fragmentation. We have not observed any evidence of conflicts between resident companies in the realm of the park.

Integrating companies among themselves has been a challenge PTEC-UFRJ has struggled to overcome. In contrast, integrating resident companies with the park itself has been much stronger: With the development of the Program for SME Residents and the Post-incubation Program, the park has structured close and frequent interactions with the companies they host (these programs have been discussed in more detail over the Enterprising section). Close relationships between entrepreneurs and PTEC-UFRJ's personnel have arisen thereout, with systematic collection of information (diagnosis) of explicit and implicit demands, and subsequent structuring of both individual and collective actions (resource sharing). As for large companies, PTEC-UFRJ has evolved to support them in discovering "non-obvious" interactions, adopting an active posture of finding opportunities for articulations and helping companies to build open innovation plans, therefore increasing the amount of potential interactions to be articulated by the park.

As for internal diversity, the main dimension is the one related to its Human Resources. The park has kept a small number of employees over its existence. And interviews suggest that small head counts are typical for Technology Parks in Brazil:

[...] When you look at the head count of UFRJ's park, it looks frightening high, right? Fifty-two people. A lot, really a lot for a park. There are parks with bigger head counts, but still [...] (Interviewee I)

However small it maybe, integration of human resources is a key are of diversity management in any organization. Analysing this dimension can provide clues on whether a institutionalization process is present, as opposed to an organization being treated as expendable (Selznick, 1957) by its employees.

Even with the low head count, PTEC-UFRJ has an additional layer of diversity not usually present in other types of organizations. This is the nature of the formal relationship its employees hold with the park. PTEC-UFRJ can hire personnel through the usual means of private contracting, under the same legal model that fully private companies can hire (aided by the COPPETEC Foundation), but it also operates with public servants linked to the university, and grad-school students hired as interns (who usually are getting scholarship grants). Public servants linked to the university and grad-school students can bring different perspectives in terms of academic views and university interests. This can for the most part be seen as positive, as consideration for public interests, and UFRJ's interests in specific, are essential for maintaining its legitimacy. We did not find evidence of any major conflict arising thereof, as said, these dynamics simply bring more weight for UFRJ's perspectives in decision making at the park. For instance:

[...] back in the day there was a public servant at the finance area, and she debated a lot: "but if the university doesn't even have toilet paper, you want to buy Neve [premium toilet paper] in here? [Laughter] [...]" (Interviewee B)

This is a minor example but does exemplify the role that public servants linked to the university play into shining more light at how the park maybe perceived by the university. Participation of public servants in the park has been defined in its master plan from the beginning; apart from the representatives at the committees, the park's General Director has to be a UFRJ servant (naturally, this also includes professors). Over the years, the number of public servants at the park has been reduced, and in 2020 there were only two, the General Director and the manager of Architecture Projects.

Integrating human resources is essential for maintaining the integrity of an organization. Successfully dealing with this challenge will be evidenced by human resources, which do not treat the organization as an expendable tool (Selznick, 1957). At PTEC-UFRJ, the outlook in this dimension has been mostly positive. Several interviewees have spontaneously manifested positive views of working at the park, with strong descriptions such as "family" and "passion" being used:

[...] it was like a family of people; it was a job, but it was also a family. Dude, that park was something really special [...] (Interviewee F)

[...] you are speaking to someone who has a much big link with, a passion for, the park, you know? I can say it is a place which I hold immense pride for

having participated in, for having worked in. It is a place which I think is an excellent idea. [...] (Interviewee B)

[...] I am very grateful for the time I worked at the park [...] (Interviewee K)

The figure of Maurício Guedes, who led the park up to late 2015, was held in high regards by PTEC-UFRJ personnel. Not only was Maurício held in high regards as to his conduction of the park, but also as one of the most influential people in the scene of innovation environments of the country:

[...] Maurício was my boss, I love Maurício with passion. It is serious, Mauricio is a person held very dearly wherever he goes. He is a very [positive] person, very nice. (Interviewee C)

[...] I mean, the figure of Maurício was very attached to the park's structure, right? I think the national innovation environment, from Anprotec to everything, felt [some impact] when Maurício left [...] (Interviewee K)

[...] When I entered [the general director] was Maurício Guedes, which was the park's and the incubator's founder, along with other people. He had this history, a lot of it, [related to] parks. He was such an enthusiast, with passion. You could see a passion [on him], right? [...] (Interviewee E)

[...] Maurício is the heart of the park, the heart, the soul, the mind, everything [...] (Interviewee C)

These are all elements that point to the classic institutionalism process happening at the park. Along with Mauricio's reputation inside PTEC-UFRJ, the park also enjoyed great reputation in the national scene of Technology Parks, for instance, being elected the best Technology Park in Brazil of the year 2013 by Anprotec, and also some international recognition, for instance, with prizes received at IASP. And this reputation was perceived and valued by the park's personnel:

[...] I have seen parks, I got to know other parks in Brazil, Recife, [some] at the south, in Foz do Iguaçu also. Parks which also want to get close to what Rio's park is, and still have a long way to go. [UFRJ's] park really is at the top, if we'd talk about it, it is at the top [level] of parks in Brazil [...] (Interviewee B)

In summary, our data supports the claim that PTEC-UFRJ has undergone institutionalization at some level, as the organization was not under the risk of being treated as expendable by its members at any point in time, on the contrary, strong ties of personnel with the park were found. Even among those who left the park, opinions regarding the park itself as a workplace were mostly positive.

However, some issues with intra-team communications were suggested to exist in terms of decision-making processes being at times too dependent on the director:

[...] The process at the park... not necessarily because of the team, but it evolved extremely centralized in the director, and a very compartmentalized

[behaviour] among the management teams at the park. The teams, to this day, talk too little among themselves [...] (Interviewee I)

In light of what has been previously discussed regarding a good relationship between members of the park, it is an important distinction to be made between general social interactions and structured communications for decision-making processes. What the last quote above refers to is the later dimension.

[...] when your compartmentalize, it looks like that management style I call Snow White. There is Snow White here, and seven dwarfs here, and Snow White speaks. And then the fight is for who gets more attention from the boss. The status of a manager depends on how much time the boss allocates to talk to him. It cannot be like that [...] (Interviewee I)

This was also backed up by other interviewees, who stressed that it was only but natural to grow into such centralized processes:

[...] I think there is also a matter of leadership style, of someone who has a more centralizing style. And here I say centralizing not with a negative connotation for Maurício, but because he was the founder, and when you are the founder you are [naturally] centralizing, right? Because it is you... you have a very clear vision of the future, and so it is natural that things evolve [this way] [...]

The history is all in your mind, the future scenario is in your mind, so it is natural that you would embrace, it is natural that you would take this attitude. And I think it is a phase, right? [...] (Interviewee A)

Lately, intra-team communication has been one of the main points PTEC-UFRJ has been actively working on improving:

[...] Something else we established too, last year [2019], was that there would be one hour per week, in which someone from the team, and it does not matter if it is the receptionist, if it is the bricklayer, electrician, or the park's director, will make a presentation about any specific topic, for the entire team. And the park stops at this [presentation] moment, except for the one guy who may be helping out in an emergency maintenance job. [...] And this has been helping the team to effectively build more rapport. [...] (Interviewee I)

Task forces have also been constructed, for instance, with a weekly meeting of all management teams, something that was not formally structured until recently.

Lastly, in terms of integrating human resources, the park's real estate maintenance team was an interesting case:

[...] my understanding was the following: the base team, the team which takes care of the cleaning, of serving breakfast, of maintenance, of reception [...], got to be people who belong to the park's team. With that, you establish a bond, you establish intimacy with those people, and you provide services that can really... at least it is [the assumption] I work with, what I believe in... you create commitment. And, when you outsource, commitment is really difficult, because the outsourced company, at any moment, changes the people who are allocated there, today it is someone, tomorrow it is someone else. And you do not get loyalty from such a team. [...] (Interviewee B)

As is clear, integration (“bonding”) between the maintenance team and the rest of the park was an explicit goal of choosing not to outsource activities that are commonly outsourced elsewhere. Evidences of such bond were reflected into very low turnover of employees allocated in this area of the park. In fact, some social interactions between maintenance personnel and one ex operations manager were noted to still persist even after years of this manager’s leaving the park.

In summary, no evidence was found of major conflicts and coalitions (Mintzberg, 1985) formed at the park. Reputation of the park and its founder have been held in high regards by the team over the years. There was no slight evidence that key personnel treated the park as an expendable tool, instead, it was found among our interviewees, majorly, deep respect for the park and mostly positive opinions of it. Naturally, it was observed that there was room for improvement in different areas, but these came in the form of constructive criticism as opposed to a manifestation of distaste for the park. While no evidence of expendability was found, a sense of responsibility for the park’s continued existence has emerged even in cases where one was about to leave the park for other professional opportunities:

[...] I loved it, I have always been passionate about it. As I said, it is a job based on love. And I developed great relationships with the companies who were there. I felt responsible for the continuity of what had been constructed. I was careful to hold meetings with all companies, we made meetings to let them know I was going to leave [the park], I made many individual meetings with them to get them ready for this transition. And I made myself available... when the new person filled the job position, I made myself available to go along with her in the companies, to make the introductions [...] (Interviewee K)

And this second example of a manager who gladly agreed to delay her leaving (for a new opportunity):

[...] I remained from September to November waiting, because there was going to be a transition, a change of directors, so Maurício asked me “oh, [...] wait a bit more”, and I said “then I will stay until November”, when the new director would take over [...] (Interviewee G)

There have been mentions of minor potential sources of conflict, such as: the decision to outsource or not outsource maintenance personnel, the contrast between quality standards of infrastructure between the park and the rest of the university, the change in identity of the park from “Rio’s Technology Park” to “UFRJ’s Technology Park”. These are clearly in regard to deciding what is best for the park, as opposed to what is best for specific people or teams, and therefore no evidence of rivalry.

This dimension, combined with the diversity of resident companies, provide enough evidence that the park has tended towards integration, rather than fragmentation, over the years. We have observed strategies of taskforces (e.g., to integrate management teams via weekly meetings), integrating departments (e.g., the weekly presentations made by personnel in any hierarchical position, in any team, for the rest of the park's personnel), liaison positions (e.g., a formal "interlocutor" designated as the main communication channel between the park and residents), and standing committees (e.g., committees with representatives of the park, the companies, the university, and government entities).

6.5 Complexity

Not enough information has been gathered to definitely assess the responses of PTEC-UFRJ to the challenge of managing complexity. But some relevant data can still be provided. In terms of adopting Information Systems and other technological tools to store, access and structure information, our data did not provide evidence that PTEC-UFRJ has acquired such technology for most of its history. Over the recent past, some improvements were incorporated through out-of-the-box software, such as My Hours and Trello, to better organize and distribute information regarding tasks and projects across all teams. In terms of a knowledge database, data suggested the classical use of ad-hoc spreadsheets and e-mail cloud storage systems to keep registries. The case suggests that Knowledge storage and transfer in the context of a Technology Park has an extra layer of complexity that may be difficult to structure into systematic digital systems: tacit and relational knowledge is central to the activities of the park; understanding the individualities of each resident company arises from close proximity and social interactions carried out over long periods of time. This is especially relevant for SMEs, considering that the post-incubation program and the Program for Resident SMEs require frequent and deep interactions with the entrepreneurs behind those companies. However, storing and transferring such tacit knowledge (i.e. deep understanding of resident companies) is not a trivial task. It was suggested that PTEC-UFRJ still has much room for improvement in this regard:

[...] We do not have, I think, a knowledge management system as well structured as it could be. [...] There is a cumulative knowledge thing about what the companies are, about what they do and all. But, without a doubt,

there is much room for improvement on this [area], I think. [...] (Interviewee D)

As the park's hierarchy and team sizes have always been lean, the issue of transferring knowledge about resident companies affects the park when some member of the team leaves, and is of special concern when one has to be substituted with human resources acquired externally, at the market, because the person who leaves may be the only one holding a good part of this knowledge. A description of such situation occurring is provided here:

[...] **much of this knowledge is complex and hard to be transferred.** What I tried to do was to register all of it [...], or a good amount of it, and share [the data I collected]. Making this entire registry of the programs, into reports. [...] So, for the post-incubation program: the objective of the program, the structure of the program, the observation spreadsheets, all of the... We did not create systems because I am no [software] developer, but I created a series of spreadsheets that would, for example, automatically generate reports. The company would fill it out, like some 500 questions, all the questions were registered, if you choose "yes" or "no" for a questions you'd generate exactly the same graphics, exactly the same reports, with a recommendation.

I tried, within the limits of my knowledge, to automate and systematize this to the maximum. But if that will remain in use, if that will be adopted, if that will be utilized, is too complex to predict because **it has much of this thing about specific knowledge mixed in... in reality, many things get lost with these changes [of personnel]** [...] (Interviewee K)

This particular case suggested that transferring data and knowledge in the case of a replacement in personnel occurring was dependant on the individual's commitment to the park and ad-hoc procedures. Other interviews confirmed that a structured process of knowledge transfer in such situation was not set in place:

[...] I would say that in a structured form, no. But this exists as a practice. [...] (Interviewee D)

The description above regards complex knowledge about resident companies, that, as suggested by interviewees, is not easily transferred due to relational and tacit qualities. As for management of easily codifiable data and information, there is no evidence to suggest major deficiencies in the park:

[...] The bureaucratic registries existed. For example, we kept records of every meeting we held with the companies. We had records of the events, a compilation of the events... [...] (Interviewee K)

As was mentioned during the challenge of managing diversity, the areas of the park "talked little [with each other]" (Interviewee I), in terms of keeping track of each other's activities and decision making. Software applications have been deployed as of recently to improve on this:

[...] When I arrived at the park, I noticed the teams did not know each other well, they talked little [with each other]. And then we started a process to integrate [them]. First, all areas committed to adding all their projects in Trello, so the areas would have access to all processes in all [other] areas. This already helped a little.

Before the pandemic – a little bit before it, it was accelerated with the pandemic –, we began to establish time-sheet controls, so we utilized My Hours, so when we went for remote work [the transition happened] very naturally. So we can observe exactly the variations, the productive gains, and eventual idleness that may happen. [...] (Interviewee I)

A common topic in the literature regarding Technology Parks is the complexity of defining the nature of performance (Phan, Siegel, and Wright, 2005; Vedovello, 2006), and, indeed, performance indicators for PTEC-UFRJ have been challenging:

[...] I found, at the park, very little performance indicators for its own process[es] [...] (Interviewee I)

The park has worked on expanding its performance indicators as of recently:

[...] we are in the last moments of closing the indicators for each area. We have already constructed a number of performance indicators for each area, people are beginning to measure [them] [...] (Interviewee I)

Complexity for the park lies mainly in the complexity of the university itself and of the companies it articulates with. PTEC-UFRJ in itself has maintained a small hierarchical, number of employees, and overall resources needed for operations. However, information and knowledge regarding UFRJ as a whole is necessary for its existence, which adds manifold to the challenge of managing complexity for PTEC-UFRJ, as UFRJ is among the biggest universities in the country.

[...] We have 1456 registered laboratories in UFRJ's database [...] (Interviewee J)

PTEC-UFRJ has worked on structured efforts for mapping the university at least since 2012. Initial efforts for mapping the university were manual, meaning the park's personnel would collect information from different sources and "take a map and highlight the academic centres" (Interviewee D). This approach produced relevant information for the park, but could not be comprehensive as the amount of personnel involved in mapping UFRJ would be out of reach for the park:

[...] UFRJ is an entire world, right? It is a university with around 65 thousand students. COPPE alone has over 150 laboratories, UFRJ has over one thousand, one thousand or two, mapped laboratories. The university is too big, so we performed this [mapping] work, which was not exhaustive. We did not do an 'X Ray' because, with the amount of manpower that we had, it would be impossible. But we did create some contact nodes [...] (Interviewee D)

Although PTEC-UFRJ was limited in its ability to map the university and create “contact nodes”, it was aided by mapping efforts conducted elsewhere in the university. For instance, COPPE’s project named “IDEA” produced booklets of COPPE’s laboratories and research in the early 2010s:

[...] there was a book about energy, a book about the environment, a book about mobility. In other words, a type of a systematized notebook of UFRJ’s offers. [Their] work was really important, we used it a lot. [...] (Interviewee D)

Other mapping efforts were also conducted by the university, producing the type of information needed by the park to carry out its mission more efficiently.

This information generated by UFRJ’s efforts entered the process of being converted into a digital system recently. As of 2020, the development of a digital platform for searching the knowledge base available within UFRJ is being built on a partnership between the park and the Dean’s Office of Graduate Programs (Pró-Reitoria de Pós-Graduação; PR-2).

[...] Now what we are developing along with PR-2 [is]: we are getting this thing that was done, which is a database, and we are trying to transform it into an app. Because [...] this app will dynamize the process so much, of finding people, of understanding [...] (Interviewee I)

One not so obvious source of knowledge and information for decision making at a Technology Park is science itself, and the university within which the park is contained. At PTEC-UFRJ, the presence of personnel with academic backgrounds has meant, for instance, that the park has itself been the subject of scientific examination performed by their own human resources. Our data identified at least two doctoral dissertations and one master thesis that have been produced about the park, and by personnel allocated at the park (both prior or during their stays). Academic literature for innovation, technology-transfer, university-industry interactions, and management of innovation environments is extensive, and indeed personnel at PTEC-UFRJ have shown themselves to be familiar with such literature. Naturally, UFRJ also has its share of researchers producing knowledge in these areas. But in addition to scientific knowledge for innovation, management, and related topics, the university is also a structure that can provide the park with necessary data, information, and knowledge for other ends. As one important example, legal matters related to Intellectual Property are supported by UFRJ’s Innovation Agency, legal matters related to interpretation of federal policies for innovation (or any other legal matter) can potentially be consulted with academics from the Law department, or the University’s Union Attorney’s General

Office. A big research university such as UFRJ is a pool of knowledge that can not only be tapped for technological innovation, but also for a diverse set of matters. Even in the absence of formal structures for such flow of information, at least some can be expected to exist through social interactions. However available, our data was not sufficient to confirm if systematic procedures and structures for tapping into such knowledge have been set in place.

In summary, the data collected suggests that over time PTEC-UFRJ has gradually recognized the need and implemented some systematic procedures for data, information, and knowledge management. Although our data is not sufficient to classify past responses as adequate or inadequate, we can assert that this dimension has not been left unattended and has been evolving as of recently.

6.6 Slack generation

The main areas of slack resources relevant to the park include: Human Resources, financial resources, physical area for resident companies, and knowledge pool available within the university.

Financial slack resources have not been prevalent at the park. Interviews suggest that up to 2015 the park was operating at a deficit:

[...] 2015, exactly, in the chronology... when he [the new General Director] arrived, everything changed, we had to think: "look, let's cut things, let's reduce the budget". At that moment, really, the park had a very big deficit, and this deficit was being, partly, covered by the foundation, because the foundation also managed the resources, it came to us through [the foundation]. Up to that moment, this was possible, afterwards this was not possible anymore. We had to do something to reduce the deficit, so it was an intense effort from the entire team, to make new public calls [for residents], to rearrange everything, to think differently. With a clear vision that we had to reduce costs but could not bring down the quality of what we offered to the companies, which was also a demand from these companies [...] (Interviewee B)

The movement PTEC-UFRJ made to reduce costs has improved the scenario, and over the last years the park has not been operating at a deficit:

[...] At the end of it, we ended the year with a positive balance of almost one million [...] (Interviewee I)

Next, Table 15, available in PTEC-UFRJ's 2019 performance report, shows a positive balance in the past three years.

Table 15 – PTEC-UFRJ's operational results for 2017-2019

	2017	2018	2019
Operational result	R\$ 2,161,602.00	R\$ 1,710,782.00	R\$ 1,947,028.00

Source: PTEC-UFRJ (2020)

One should consider that the park does generate a considerable amount of income from its resident companies, the majority of it are handed directly to the university, not kept for the park's operation and investment. Therefore, one should be careful to not confuse operating at a "deficit" for some years with destroying value for the university.

The park has to deal with limitations related to its public (governmental) nature, one important limitation that arises thereof is that there have been no venues for income growth in periods where no new companies joined the park. With the exception of public calls for investment bids (public "competitions"), made by entities such as FAPERJ and FINEP, who grant financial resources for Technology Parks. However, these governmental resources are directed towards investment in specific projects (presented by the park), such as the construction of a new building, as opposed to general resources that could be freely applied by the park. Figure 16 (in section 5.2.3) presented the amount of funds PTEC-UFRJ collected via FINEP for the years 2015-2018, as presented on their sustainability reports.

In addition to the unpredictability that stems from the fact that these funds have to be earned via public competitive processes, there are also notable problems that exist even after being selected to get the funding. For instance, as mentioned before, the Cubo project was delayed several times, with a ten-year gap between its conceiving and finishing construction, because it was financed by FINEP resources, which had problems along the way in delivering the money. The interviewee below provided another example of an ongoing issue:

[...] There was a public calling by FAPERJ, 2014 or 2015, for Technology Parks, and UFRJ's park won it. To this day it has not been paid yet... to this day it wasn't paid. [...]

[...] and there are difficulties for planning. Because in November [2019] we received a firm promise, from FAPERJ's president, that it would be paid at that year, because they had to fulfil the year's budget, etc, etc, etc. There was a ceremony in the Municipal Theatre, where we get the diploma and whatnot, with the governor, with everything. That was in November. We run, get through Bradesco's bureaucracy, open the account... And you know there is a very short time to apply the budget, right? One of the biggest hardships of public service is to realize the budget, because bidding time is too long and whatnot,

and you have to commit the resources. So you make a planning, a Tour de Force with the team: “the resource will go here, we need to make a public bidding for this, this and that, the problems are such, the reference terms. Let’s get everything ready!”. And then, it is not paid [...] (Interviewee I)

This brief description of such income source is to conclude that although the park has the option of acquiring financial resources through these entities, and has been successful in doing so multiple times, these can hardly be accounted for as slack resources: (a) there is a competitive phase for these to be acquired, (b) the moment they arrive at the park, their destination is already set, (c) delays and problems in receiving funds are not rare.

Budget limitations have affected different areas. To illustrate, the interviewees below suggest that budget limitations were impactful for the size of teams, and for communication activities:

[...] [the challenge] of performing communication without money, right? Because, for better or for worse, we are in a public [government] environment, so there are budget limitations. [We] would love to have performed thousands of Instagram live streams, inviting everybody and his brother... right? But you need to be very creative to do that. But that is it, an internal budget challenge. [...] (Interviewee C)

[...] There was a big budget restriction, right? The park [was] not profitable. We’ve got two sources of income at the park, there is the occupation fee – concessions -, and service fees - which is paid for the services provided. The “rent” per-se goes straight to the university, the “condominium” part is distributed between UFRJ, the park, and the foundation [COPPETEC]. There is a financial arrangement which I really do not know the details of, but I know that what was left for us, to operate, to pay the team, was too little. We had to operate with lean teams... [...] (Interviewee K)

In summary, slack financial resources have not been strong during the park’s lifetime, but there is evidence that over the last few years it has in fact improved.

As for slack Human Resources, these have also not been observed in great abundance. Human Resources did not display much room for idleness. At times, an overload of work could be observed.

[...] I was a scholarship holder, so my workload was 20 [weekly] hours... But alright, I did not stay there for 20 hours, right? I stayed there much longer than people who worked 40 hours. At the end of the day there was some overload, yes. [...] (Interviewee K)

[...] [My working hours] were mornings only, from 9 to 13, around that. But I stayed until 18 everyday [...] (Interviewee F)

A general tendency for just-in-time acquisition of Human Resources coupled with a lean hierarchical structure suggest that slack Human Resources is not generated

systematically. This is also affected by the budget limitations mentioned before. Slack might exist in terms of the skillset possessed by personnel allocated at the park. PTEC-UFRJ has acquired highly qualified personnel, in terms of higher education and past experiences related to the management of innovation environments, and entrepreneurial ambition to push the park further (coming up with projects and plans for the future, as opposed to solely performing their given tasks).

[...] I think we have an adequate team to do more than we [currently] do, ok?
 [...] Because these people are highly qualified, this is the truth. I found at the park, in a way, a mature team. [...] These people have great [educational] backgrounds, and very good professional experience [...] (Interviewee I)

Potential Human Resources are also a dimension to be considered: for instance, the good impression provided by ex-employees of the park may suggest that the park is an attractive place to work, coupled with the positive image that PTEC-UFRJ has, in general, among innovation players in the country, the park should have an upper hand in attract resources should it need. The university in itself provides a pool of potential human resources to the park, as students may be drawn to the park due to the network of social connections (which indeed was observed); in addition, the park has the ability of including public servants linked to the university. One issue related to potential human resources was brought up during interviews, related to an apparent lack of qualified Human Resources for management of innovation environments in general, for it not being subject of widespread formal educational programs in the country:

[...] We had difficulties in finding people with the [right] profile, and I think this was a challenge even after I left, so much so that some programs which I managed ended up being discontinued. Because it is hard, really, there aren't professionals on the market with such a profile. And there is the matter of demand, right? Because it is really intense [...] (Interviewee K)

Physical area for resident companies has shrunk fast following the pre-salt rush. The park still has some room for large companies and spots available at shared spaces. However, PTEC-UFRJ itself has observed that such spaces may run out in the near future. As of most of the park's history, this has not been a problem. Today, the park is working on its digital transformation, and heading towards associated companies that need not be physically located at the campus. In fact, the park has already had some examples of articulations with non-resident companies (Itaú,

L'Oréal). The relevance of this slack resource (physical space) may be reduced or rendered irrelevant as a result of these efforts.

Lastly, slack resources related to knowledge and scientific expertise is central to the success of the park. Naturally, these resources are pooled from the university itself. In this regard, PTEC-UFRJ is well guarded as part of UFRJ's ecosystem, a university that has been traditionally recognized as one of the top research universities in Brazil, with strength in diverse knowledge areas, thousands of laboratories, and renowned researchers.

6.7 Synthesis of the analysis

The analysis of PTEC-UFRJ in light of its responses to Fleck's (2009) growth challenges has been performed over a single phase comprising its entire lifetime, for the park is in its 17th year of operations as of the execution of this work. Ideally, the analysis of an older organization would be split into two or more well-defined historical phases, as to allow a direct comparison of responses to the challenges across phases in order to assert whether improvement or deterioration of adequate responses to each challenge could be observed. PTEC-UFRJ's young age has meant that this additional level of cross-phase analysis could not be performed. Nevertheless, a longitudinal in-depth analysis of its entire lifetime could still be performed in light of the growth challenges and sufficed to assess whether the park has acquired the necessary (but not sufficient) conditions to deal with its growth heading into the future. The figure below summarizes our final assessment. A synthesis of each challenge will be provided to support the conclusions graphically represented here:

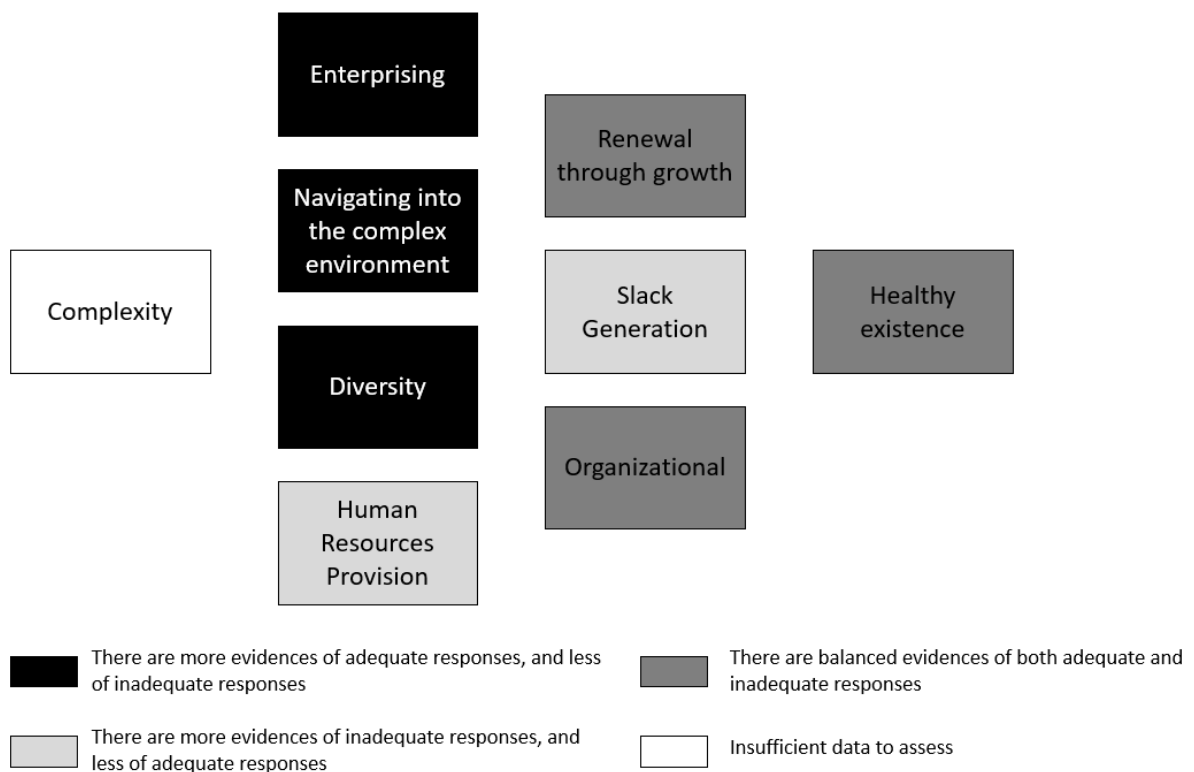


Figure 20 – PTEC-UFRJ's responses to the challenges of growth
Source: created by the author

PTEC-UFRJ was idealized starting in the early 1990s as a project lead by Maurício Guedes inside UFRJ. It was an ambitious goal considering that (a) Brazilian private companies were historically not very engaged in R&D&I, (b) the concept of Technology Parks was not diffused in the country, and (c) little to no legal frameworks were set in place to support innovation environments and university-industry interactions. After an initial period of difficulties in finding resident companies, an environmental opportunity emerged through the pre-salt rush. Since then, PTEC-UFRJ managed to grow into one of the most prominent Technology Parks in Brazil, even gaining some international recognition. Concentration in the oil & gas sector quickly showed its risky nature with the 2014 crisis in the sector (global but accentuated in Brazil). PTEC-UFRJ however never departed from its multi-sectoral strategy and managed to acquire resident companies from other sectors over time. During this rapid growth period, we observed systematic structuring of teams and services, some expansion of scope, and quick adaptations to its internal organization and contractual relations.

Enterprising qualities as defined by Penrose (1959) were identified as being present over its history. Maurício Guedes and early supporters of the park indeed showed great ambition for the mere fact of pushing the creation of a Technology Park in Brazil given the environment described above. In this initial effort, fund-raising abilities were crucial in order to convince the local government to take part in funding PTEC-UFRJ's initial basic infrastructure. Fund-raising in an entity such as PTEC-UFRJ is constrained by its strict regulatory environment, for the park carries a public (governmental) character. Considering what is possible within these regulations, fund-raising continued to be observed over its lifetime, for instance: (a) partnership with Petrobras that resulted in shared buildings for SME residents and the park's management facilities, (c) financial support from COPPE's Incubator and COPPETEC during its initial stages, and (d) successfully acquiring funding from public entities such as FINEP and FAPERJ. Versatility was verified through the park's further expansions of scope in terms of types of companies welcomed (sizes, sectors, and maturity) and services provided (SME Resident Program, post-incubation program; CrowdRio, Startup Bio, Coworking, Softlanding, etc), with even instances where interactions with non-resident companies, without contractual relations, have been established (e.g., Itaú, L'Oréal). Versatility was also found in expanding the scope of projects developed

by the park in partnership with diverse areas of UFRJ, with or without companies, such as a public art gallery and other projects listed in tables 10 and 11. Judgement was indirectly assessed by the lack of any evidence that would suggest PTEC-UFRJ to have been exposed to excessive risks over its lifetime.

As for the park's environment, it was observed that the most challenging dimension was that of institutional pressures, for the park has been subjected to strict regulations on all government levels and within the university. In addition to strictness, legal uncertainty was observed to be present and affecting the park even with improvements to the legal framework in 2004 and 2016. Its identity has been firmly grounded in being part of UFRJ, to which the park owns its very reason of existence: its legitimacy depends on successfully achieving articulations between companies and the university, and these should be perceived as valuable by UFRJ. It was observed that its legitimacy in the eyes of stakeholders internal to the university could not be taken for granted, being one of the challenges formally recognized by the team. Over the years, the park has actively worked on this relationship by going beyond articulations for technological R&D&I projects. The formal structuring of the Institutional Development team and the Internal and External Communications team have ensured that communication and partnerships with diverse areas of the university were constantly sought. Such structuring has also expanded the scope of cooperation modalities performed by resident companies, among other things. We found evidence for response strategies to institutional pressures ranging from Acquiescence to the more active tactics of Influencing (Oliver, 1991). The competitive environment with innovation actors external to the university was deemed not strong: our interviews suggested the relationship between parks was more of cooperation than competition, and competition with other external innovation environments was less relevant for the park's distinguished orientation towards UFRJ (an attribute not identified in any external actor). The natural and social environment was assessed as not posing critical pressures in the short run, but, as a general expectation, long term pressures may be relevant over the long run, and PTEC-UFRJ was found to be anticipating such pressures by engaging in environmental and social sustainability projects. In summary, responses to the challenge of Navigating into the Complex Environment have been deemed majorly adequate.

Analysis of Diversity management at PTEC-UFRJ had first to be divided into three dimensions: (a) diversity regarding resident companies, (b) diversity regarding the university, and (c) diversity of the park's internal resources. Throughout its entire lifetime, the park has not exceeded 60 concurrent employees. Furthermore, the highest value of the park's core activities relies mostly on services rendered by Human Resources, as opposed to machinery or software. The conjunction of these two properties suggests that heterogeneity of resources internal to the park has been kept low over its lifetime. As PTEC-UFRJ effectively functions as a middleman between companies and the university, diversity in these two sides is of concern to the park's proper functioning. Diversity of companies regard sizes, sectors and maturity. The park has received large companies, SMEs, and nascent entrepreneurs working in different sectors. The challenges imposed to PTEC-UFRJ stemming from such diversity refers to two main areas: (a) integrating companies among themselves and (b) integrating companies with the park itself. SMEs manifested interest in developing relationships with large companies for commercial purposes. We found that integrating companies for this end was a challenge PTEC-UFRJ has worked on, but not much could be achieved by the park alone. Instead, our data suggests that, as of recently, there has been a trend in the general market, where large companies gradually move towards a higher opening for engaging with SMEs, producing some success cases of such relationships within the park. As for integrating companies with the park itself, PTEC-UFRJ has been much more successful: starting in 2014, the Program for SME Residents and the Post-Incubation Program ensured frequent meetings between entrepreneurs and a designated person/team at the park. Such programs allowed the park to understand ("diagnose") their resident companies in all major business dimensions, as well as developed close social ties between entrepreneurs and the park's team. Resources sharing was present through the development of "collective actions" to address business challenges of multiple residents at once. On the other side, diversity within the university is a key point of interest for the park, as historically UFRJ holds academic expertise and diverse areas, thousands of laboratories and is among the universities producing the highest amount of research output in the country. This area however lies much outside PTEC-UFRJ's scope of direct influence, and the challenges in here are best described in terms of navigating the environment and managing complexity. Diversity of internal resources to the park was assessed as

displaying mostly adequate responses, as we found no evidence whatsoever of political arenas forming, sub-coalitions or any major internal conflict. No data collected in this work could suggest the park was at risk of being treated as expendable by its Human Resources, much the opposite: personnel, both current and past, have shown great respect for the park as an institution and reported mostly positive attitudes towards the teams they were involved with. There was one evidence of inadequate responses in regard to decision-making structures and keeping track of tasks being performed across teams, that is, less than ideal intra-team coordination. This dimension is being gradually worked on and there is evidence to suggest that improvements have already been made. Finally, although there is not enough data to infer the present of a fully-fledged institutionalization occurrence, there is evidence of at least some signs of it: PTEC-UFRJ's reputation was found to be held in high regards both inside it and externally on a national scale. The founding figure of Maurício Guedes holds as a strong positive image in the park even after his leaving. Words such as "passion", "family" and "love" have emerged as descriptions of work performed at the park, formal structuring and improvements of hierarchies and processes have been sought, and the establishment of rites such as events to present new resident companies to the old ones, and events to integrated personnel intra-teams have been established.

Management of Human Resources was deemed to be the most challenging dimension in our analysis of the park. Provision and retention of personnel are of special concern to the park due to relational and tacit knowledge developed over long periods of interactions with resident companies and diverse areas of the university. Codifying and transferring such knowledge is difficult, and finding new professionals at the market who hold such specific knowledge (about these specific companies and university) can be virtually impossible. PTEC-UFRJ has acquired highly qualified Human Resources in terms of academic and industry backgrounds, who tended to be personally motivated and passionate about the topics of innovation and management of innovation environments such as a Technology Park. Our interviews suggested that such Human Resources are not only hard to find in the job market, but also highly demanded. We found that two main issues put pressure on the park's ability to hold such resources, (a) not much financial slack available and (b) a "lean" hierarchy. It was suggested that highly qualified personnel who do not hold chief management positions

would naturally be expected to come by new opportunities elsewhere, while the park would be unlikely to offer high prospects of professional/hierarchical growth over time. Accentuating these two points, PTEC-UFRJ has also acquired personnel, to fill key positions, under scholarship grants. It was observed that this has resulted in some higher difficulties not only for keeping such personnel, but also for transferring knowledge to substitutes, since, at times, a new individual could only enter the park after the last scholarship holder effectively left. The high standards needed by PTEC-UFRJ for their personnel coupled with a (self-declared) low availability of such Human Resources in the market has also impacted the modes of acquiring these resources. Except for the position of General Director (and apart from real estate maintenance and support staff), acquisition of Human Resources was not observed to follow systematic procedures. Our data suggests that acquisition of new personnel tended to occur through networking of people involved in the park and indications. This work has not investigated the extent of availability of Human Resources with the profile needed by the park in the region. However, assuming low availability of qualified Human Resources is in fact present, as was pointed out by some interviewees, this “head-hunting” mode of acquiring Human Resources, as opposed to more structured/systematic formal processes for recruitment and selection, may not necessarily characterize an inadequate response. Succession of Human Resources has had a mix of both internal promotion and external acquisition, but our data suggests a heavier tendency towards external acquisition (there were special cases of acquisition of Human Resources from COPPE’s Incubator, formally an external organization however with close ties with the park). Again, apart from the position of General Director, structured procedures for succession did not emerge from our data.

In other relevant dimensions of this challenge, adequate responses were observed: (a) training and education of Human Resources was supported by the park, and (b) provision and retention of Human Resources at the lower bases of the hierarchy has been constantly strong. However, PTEC-UFRJ’s responses to the challenge of provisioning Human Resources was deemed to show more inadequate than adequate responses as the emphasis of this challenge, what carries more weight, is the timing of provisioning (anticipated, just-in-time, or delayed). For the observations mentioned above, PTEC-UFRJ has been classified as tending towards just-in-time provisioning of Human Resources.

The challenge of managing complexity was the single challenge of the model left unassessed, for we believe the of data collected in this work is not sufficient to assert PTEC-UFRJ's responses as adequate or inadequate. As was true for the discussion surrounding the extent of diversity in the park, PTEC-UFRJ may at first appear as not posing much complexity due to its relatively "lean" size (hierarchical positions, number of employees, geographical locations, etc), however the scope of complexity expands manifold when taking into consideration the university and companies with which the park has to remain constantly informed about, interacting with, and articulating both sides. Some evidence was found that databases of information and digital systems have been gradually implemented over the years. However, our data is insufficient to assess how adequate such databases and systems are to support the park in its decision-making processes and operations.

Moving beyond the basic five challenges of growth, we have analysed slack-generation, moving towards the right-most side of the model (Fleck, 2009). The most critical slack resources for the park were deemed to be (a) financial, (b) Human Resources, (c) UFRJ's knowledge-pool, laboratories and researchers willing to engage with companies and the park, and (d) available physical spaces. This last item however is expected to lose relevance as PTEC-UFRJ is expected to embrace associated, non-resident, companies. Financial slack was observed to be deficient for the most part of the park's existence: interview data asserts that PTEC-UFRJ was operating under a deficit up to 2015. Gradual improvements have been made over recent years, with a positive trend moving into the future. Although weak, financial slack has to be considered within the context of strict regulations and PTEC-UFRJ's judicial form as a public (government) entity, in addition to its formal link to UFRJ as a partial recipient of monetary value generated at the park. Human Resources slack was also deemed weak, for our data suggests little to no idle time was found at the park, with occasional work overload being mentioned by some interviewees. Some form of slack was considered in terms of the skillset of Human Resources, for the park holds highly qualified personnel capable of rendering diverse services. Finally, UFRJ's knowledge pool, laboratories, and researchers provide the biggest slack resource available to the park. This dimension is connected to the park's responses to navigating its institutional environment, for the boundaries of slack resources coming from UFRJ (available to the park) are defined by the willingness of researchers to engage with the companies

through the park. As mentioned, we found the park's responses in the area to be adequate, thus, availability of these last-mentioned slack resources can be deemed to be continuously expanding. A good example here is the presence of some UFRJ's laboratories inside the park (e.g., LabOceano, Lamce, etc). These laboratories do not belong to PTEC-UFRJ, but their presence at the park resulted directly from efforts to strengthen the park's attractiveness and value offering.

The central mechanisms of Renewal Through Growth and Organizational Integrity can be summarised as a function of the responses to the pairs of Enterprising/Navigating the Environment and Diversity/Human Resource Provision. Table 16 below summarizes the main information collected in accordance to each challenge, classified as evidence of adequate or inadequate responses, to yield the overall assessment visualized in Figure 20:

Table 16 – Main evidence of responses for each challenge

Mechanism	Growth Challenge	Evidence
Renewal Through Growth	Enterprising	Fund-raising through diverse government entities;
		Diversified portfolio of resident companies: sizes and sectors
		Expanded scope of services: business support for SMEs and programs for nascent entrepreneurs; softlanding; coworking;
		Articulations with non-resident companies;
		Diversified portfolio of events;
		Extending beyond technological R&D&I;
		No evidence of excessive or unnecessary risks being taken;
	Navigating into the Complex Environment	Co-evolution: cooperation with Technology Parks and other innovation environments, nationally and abroad;
		Scanning the environment: through associations, personal relationships with managers of other parks and innovation environments, frequent meetings with residents, committees composed of diverse stakeholders, participating in policy discussions (university and government);
		Responses to institutional pressures: Acquiescence (compliance), and Influence (co-opting, manipulating);
		Anticipated response to natural and social pressures: sustainability projects;
		Juridical Form: anecdotally described as "a qualified inexistence", PTEC-UFRJ is still to define and adjust its juridical form to take advantage of the new regulations passed after its original conception. For the park pre-

		dates such regulations, its juridical form was made "what was possible at the time".
Organizational Integrity	Managing Diversity	Close relationship between SME resident companies and the park's team;
		Some established social practices to integrate new companies and to integrate personnel across teams;
		No evidence of Human Resources treating the park as expendable;
		No evidence of political arenas and major internal conflicts;
		Reputation: PTEC-UFRJ and its founding figure, Maurício Guedes, have been held in high regard both inside the park and nationally. This sense of good reputation has been pervasive across PTEC-UFRJ's personnel;
		Challenging intra-team coordination for decision making and keeping track of tasks;
		Not strong connections with large companies beyond their R&D centres;
		Difficulties integrating SMEs and large companies among themselves;
	Human Resources Provision	Strong provision and retention of Human Resources at the lower levels of the hierarchy;
		Training and education support;
		Tendency towards just-in-time acquisition of Human Resources for the high skilled job positions;
		Lean hierarchy and small financial slack make retention of highly qualified human resources more challenging;
		Instances of critical positions being filled by scholarship holders: time limited and tendency towards just-in-time substitution;
		No evidence of structured succession plans (except for the position of General Director);
		No evidence of structured recruitment and selection processes (prevalence of ad-hoc head-hunting and indications via pre-established networks)

Note. White background – adequate responses; Gray background – inadequate responses;
Source: created by the author

In light of the two archetypes of organizational success and failure (Fleck, 2009) – self-perpetuating, corresponding to the polar side of strong adequate responses to all challenges of growth, and self-destructive, on the opposite side –, our data suggests a balanced mix of responses during PTEC-UFRJ's first phase of existence. As such, the park, as of yet, cannot be classified as fitting a self-perpetuating archetype. The challenge of Human Resources Provision has emerged as the dimension with the lowest evidence of adequate responses: holding the most weight here were (a) the

assessment of timing (anticipated, just-in-time, or late), where a tendency for just-in-time acquisition was found, and (b) a lack of evidence for structured succession plans and acquisition processes. We have noted that the challenges of Human Resource Provision was heavily affected by factors such as (a) high demand and low availability of qualified professionals in the market, (b) low levels of financial slack resources, (c) lean hierarchy with little room for ascending, (d) highly qualified personnel who can easily come across opportunities elsewhere. Accentuating the importance of anticipated acquisition, internal succession and retention of human resources was the marked presence of tacit and relational knowledge accumulated by personnel.

The mechanism of slack generation has direct impacts on both central mechanisms of the model, Renewal Through Growth and Organizational Integrity. Our assessment suggests that slack generation, in summary, tended to be low. While PTEC-UFRJ's responses to the challenges of Enterprising and Navigating the Environment were assessed as displaying mostly adequate responses, the mechanism of Renewal Through Growth was assessed as balanced (as opposed to strong), for adequate slack generation is a necessary condition to set in motion the mechanism of continuing-growth (Chandler, 1977 apud Fleck, 2009).

Notwithstanding the considerations above, mostly adequate responses were found elsewhere, in the challenges of Enterprising, Navigating into the Complex Environment, and Managing Diversity. All in all, we finalize the assessment of PTEC-UFRJ's responses to Fleck's (2009) challenges of growth by considering its still short history: roughly ten years have passed since the park has received its first resident company, and only 17 from its official inauguration. The evidence of adequate and balanced responses to most challenges in such short time span may indicate a trend towards approximation to the self-perpetuating archetype, however, some of the necessary conditions are yet to be met.

7. Discussion

7.1 Continued existence and social relevance of Technology Parks

The theoretical model applied for the study of PTEC-UFRJ – the five challenges of growth (Fleck, 2009) –, is one that arises mainly from the strategic management literature, but is not directly related to innovation and the assessment of innovation environments in specific. The model proposes that growth, for any type of organization, poses specific challenges, and how organizations respond to these challenges can reveal patterns that point towards continuous and healthy existence (long-term success) or to self-destruction.

Meyer and Zucker (1989) set forth the concept of “permanently failing organizations”, which can be observed in both public and private organizations alike. Technology Parks “owned” by public universities run the risk of entering such a state of existence if, for example, political support for their existence persists even in the absence of production of relevant innovation as results from their activities. While we have analysed one case of a Technology Park in terms of the challenges it faces for self-perpetuation, we reckon that the mere continued existence of a Technology Park is not enough to assert whether or not the finalistic objective of producing innovation through university-industry interactions, leading to regional socio-economic benefits, is being achieved at satisfactory levels by any measure. This is noticeably clear by the lack of discussion in this work surrounding the actual instances of innovation generated through PTEC-UFRJ, successful cases of articulations, and little data regarding other social benefits that are also pursued by the park. Of course, this in no way suggests that these were not achieved by the park or have been weak, rather, the objective and methodology of this work were not directed towards measuring socio-economic impacts and innovation generated at the park, being solely concerned with management practices.

Indicators of size and financial slack, included in the analyses of the challenges of growth set forth by Fleck (2009), can often be related to performance as measurements of growth and economic efficiency. However, as DiMaggio and Powell (1983) stated, economic efficiency cannot be assumed to necessarily explain the continued existence of organizations, the existence of “permanently failing organizations” observed by Meyer and Zucker (1989) support this argument. While growth and economic efficiency can be constituent parts of “performance”, other

factors, at times intangible, can also be conceptualized as dimensions pertinent to performance. These are manifold, and the literature has identified, among many others, innovation, social impact, and usefulness of initiatives as potential measures of performance (Diefenbach, 2009, p. 900). As indicated by Anprotec (2008), Technology Parks in Brazil fall mostly within the “third generation” of parks, and a defining characteristic of these is that they are explicitly pursued as tools for promoting socio-economic development of regions and countries, and the medium employed to achieve this goal is to generate innovation through interactions between companies and research institutions. As such, we deem social impact and usefulness of initiatives as perhaps the most relevant measures of performance for Technology Parks (in similar contexts to the one analysed in this work, that is, juridical form of a public entity and part of this third generation of parks), where measures of innovation may serve as a proxy to performance, given that (a) social impact may prove difficult to measure directly, and (b) the literature has very solidly validated the positive link between innovation and socio-economic development (see Cameron, 1998).

As explained through the Triple Helix model (Etzkowitz and Leydesdorff, 2000), Technology Parks constitute hybrid organizations that arise at the intersection of the helices. Although hybridization blurs the lines between public and private, some degree of publicness (e.g., Boyne, 2002) is never lost. This is of extreme importance given that, as Diefenbach (2009) observed, there are many traps that can arise out of applying business management ideas into public organizations, one of which is precisely that the essential nature of performance may be lost due to political artifacts, technological limitations (for measurement), and the introduction of market- and stakeholder- orientation.

While the propensity to self-perpetuate, in terms of the theoretical model here applied, is a necessary condition for Technology Parks to achieve their essential goal, it is not sufficient to assert their level of performance regarding the task of positively impacting socio-economic development over time. Therefore, the contribution of this work, thus far, lies outside the scope of the literature on innovation and of Technology Parks specifically, instead, being purely directed towards the strategic management literature, contributing to the body of research that has tested the applicability of the challenges of growth set forth by Fleck (2009), in specific, its applicability to the analysis of hybrid organizations.

However, much data has been collected regarding one of the most prominent Technology Parks in Brazil, where some topics have been identified as potentially useful insights for other Technology Parks in the country. Especially for those parks that are still in their very early years of operations or still in planning/implementation, some challenges that have occurred throughout the history of PTEC-UFRJ may be areas where these younger parks could benefit from reflecting upon and planning their responses in anticipation. This constitutes the secondary part of this work. Assuming an exploratory instance, the next section will list and synthesise lessons learned from PTEC-UFRJ's case which can potentially be useful for other Technology Parks in Brazil under similar contexts (i.e., public juridical form and linked to a public university), that is: what challenges faced by PTEC-UFRJ over its lifetime could also be faced by other Technology Parks in Brazil?

7.2 Lessons learned from PTEC-UFRJ

In this section we will address the relevance of data gathered from PTEC-UFRJ for other Technology Parks attached to public universities in Brazil. As was mentioned before in this work, the emergence of Technology Parks is a relatively young phenomenon in the country, which, as shown by CDT/UNB (2019) has gradually gained popularity over the last decade or two. A number of Technology Parks are therefore still taking their very first steps, with many others already planned to come. Public universities are historically, in Brazil, the institutions that produce the highest research output. Therefore, Technology Parks linked to public universities may be the most relevant type of Technology Park in Brazil. As such, this work seeks to contribute to the literature on Technology Parks by capturing the most relevant challenges identified throughout the analysis of PTEC-UFRJ in the previous section. In this sense, Fleck's (2009) theoretical model served as a guiding light to structure data collection, and the output of this work is divided into two parts: (a) analysis of PTEC-UFRJ's response to the challenges of growth, and (b) lessons learned from PTEC-UFRJ's case that can contribute to other Technology Parks linked to public universities in Brazil. The table below lists the main challenges compiled from PTEC-UFRJ's case. We will proceed to detailed discussion of each item for the remaining of this section:

Table 17 – List of challenges derived from PTEC-UFRJ's experience

Challenges
Legitimacy beyond technological R&D&I projects;
Long-term relationships vs ad-hoc demands;
Obvious vs. non-obvious interactions;
Tacit and relational knowledge;
Retention of highly skilled labour;
Integrating companies among themselves;

Source: created by the author

7.2.1 Legitimacy beyond technological R&D&I projects

Acquiring normative value, legitimacy, is one of the critical dimensions emphasized by the theoretical model utilized in this research to analyse PTEC-UFRJ. Emerging from this case analysis is the proposition that maintaining legitimacy, in the eyes of the university to which a Technology Park is linked to, can often lie beyond articulations for technological R&D&I projects.

In line with previous works such as Perlin et al. (2018), Matias-Pereira and Kruglianskas (2005), Plonski (1995), who have found the theme of university-industry interactions to be somewhat of a controversial topic in Brazil among members of the academia – also present in the international literature (e.g., Etzkowitz 1983, 1998; Shane, 2004; Owen-Smith and Powell, 2001; Eagleton, 2015) –, our case also confirms that the legitimacy of an institution such as a Technology Park, aimed towards promoting such interactions, indeed cannot be taken for granted within academia. Although some interviewees pointed out that the scenario has improved over the last two decades, the presence of companies inside a university and interactions with the industry are still challenging topics.

Our case study suggests that Technology Parks owned by public universities in Brazil should give extra attention to the matter of acquiring normative value from inside the university they belong to. All members of the university are legitimate stakeholders (in terms defined by Miles, 2017) of the Technology Park, regardless of currently being, or having the interest in becoming, collaborators of the park (i.e., participating in interactions with companies or the park itself), and, provided the formal mechanisms for participation in decision making processes inside the university, may influence the very existence of the park over the course of time.

Our case study suggests that being successful in articulating interactions, and periodically generating successful innovation cases, may be necessary but not sufficient for a Technology Park to acquire and sustain legitimacy within the university it belongs to. At least not in contexts where university-industry interactions are found to be controversial to any significant extent.

To aid in acquiring and sustaining legitimacy, a Technology Park may reach beyond Technological R&D&I topics and activities. In the case of PTEC-UFRJ, a dedicated team/area was set in place to take care of projects that lie outside R&D&I-related articulations. Sustainability projects (social and environmental topics) are developed by this team (not only for the university but also inclusive of the wider local community). Projects to benefit the community (inside and outside the university) are produced by the park alone and/or in partnership with diverse areas/individuals from the university. Many of these enter the realm of cultural projects, such as periodic thematic events that showcase the work of students, professors, and employees, in areas such as gastronomy, music, and general arts (and exhibitions of artworks from recognized artists external to the university that also benefit the community and generate engagement). Often, these projects can also involve the participation of resident/associated companies, sponsoring or otherwise supporting projects, and this, in turn, creates yet another venue for interactions between the university and companies. Reaching out into social, environmental, and cultural topics allows a Technology Park to engage with members of the university that otherwise would likely be far removed from the activities performed by the park, for some knowledge areas (humanities and basic research in general) may simply not hold as many opportunities for R&D&I interactions as some more applied areas of research.

Other ways in which Technology Parks can generate benefits to the academic community include providing job opportunities for students in the park's management, and to formally stimulate resident/associated companies to also do so. In the specific case of PTEC-UFRJ, the park has counted with both current and ex-students of the university as part of their team in a number of occasions. Furthermore, companies have an incentive to hire students as interns hardcoded in their contractual relationship. By doing so, companies comply with part of their mandatory cooperation clause established with the park.

In a similar fashion, universities engaged in the process of innovation and university-industry interactions, to the point of possessing a Technology Park, will usually possess many instances of enterprises generated as spin-offs, which may be housed at the park, in standalone incubators (university incubators separated from the Technology Park), or even operating completely on their own. Depending on the stage of development and the specific history of each spin-off, current students, professors and employees of the university may concomitantly be involved in these enterprises, and even when said entrepreneurs are now dedicated to the spin-offs full time (i.e., not formally part of the university anymore), network ties with the academic community can remain strong. Technology Parks may therefore also find a venue to benefit the local academic community and acquire legitimacy, at the same time, by prioritizing commercial relationships with enterprises that have some kind of link with the same university. This is not to say that parks should go out of their way to contract unneeded services for the sake of benefiting the community, but, whenever necessary and available, such prioritization could be welcomed by the community. In addition to spin-offs, other forms of professional groups may also be available, such as Junior Companies.

In the case a university holds a decentralized innovation ecosystem, with multiple reasonably independent actors besides a Technology Park, special care for nurturing a relationship with other actors in the ecosystem will also be necessary. A decentralized ecosystem may have to rely in the pro-activeness of each actor in order for communication to flow adequately, and to avoid and solve eventual conflicts. There is a risk that the nature of the relationship between actors of the ecosystem will abruptly change along with any changes that happen in personnel and leadership of any given actor. Here, there may be a difficult balance to be made, where too much rigidity, bureaucratization, labelling, and otherwise formalization of the relationship between each actor of a university's innovation ecosystem could potentially impact the speed and effectiveness of the entire mechanism, but abrupt changes and uncertainty in the nature of the relationship between actors, and their roles, could be detrimental to the relationships that exist.

In summary, Technology Parks linked to public universities in Brazil may need to engage in topics beyond articulations for R&D&I in applied sciences in order to acquire and maintain normative value (legitimacy). This means: (a) entering the realm

of social, environmental, and cultural projects, which should allow a Technology Park (and companies) to interact with diverse areas of the university that would otherwise be alienated from the activities performed by the park, (b) other forms of generating benefits for the local academic community (students, professors/researchers, and employees), such as job opportunities and commercial relations with spin-offs and other professional groups linked to the university, and (c) maintaining a stable relationship, and frequent communication, with other actors involved in the university's innovation ecosystem.

7.2.2 Long-term relationships versus ad-hoc demands

Technology Parks operating in models similar to the case analysed in this work will have a focus in building long-term relationships with companies, where expectations of periodic interactions between these companies and the university (or universities) represented by the park arise thereout. Companies are curated to join a park, and establish formal (contractual) relationships with said park, either by physically moving into the Technology Park (partly or fully) or by becoming associated (but non-resident) companies. From such formalized relationships, expectations of frequent, periodic, interactions with the park and university can often be present. In the case of PTEC-UFRJ, this expectation is explicitly hardcoded into a contractual clause of mandatory cooperation. It is our understanding that expectations for long-term, periodic (and frequent) interactions between companies and the university will naturally be high when any, or both, of these are true: (a) companies physically join a park, in shared buildings or individual facilities, located inside a public university's campus, or any other public land, and (b) the Technology Park renders services beyond passive mediation/articulation of demands for interactions (e.g., business consulting services, real estate/facilities services, information delivery services, training programs, and more). If one or both of these are true, at least two contributing factors (for high expectations of frequent interactions) emerge: (i) for the land in public universities and the labour employed to deliver services fall in the category of public resources, pressure exists to ensure that continuous societal gains result from their continuous usage, and (ii) physical space and labour are limited, therefore, Technology Parks have an incentive to prioritize resident companies with the highest potential for continuous

interactions, rather than those which may be interested in one-off projects, or those which lack the ability to explicitly foresee future interactions (even when interested in building long-term relationships).

Expectations regarding the frequency of interactions may be a difficult point to balance, especially for geographically enclosed Technology Parks that house companies inside their land area. On the one hand, the limitation of physical space available can understandably pressure a park towards assembling a group of companies that would maximize the amount of interactions happening with the university at all times. On the other hand, timing the process of innovation and the need for R&D&I-related interactions that naturally arise inside companies is arguably an unrealistic goal to be pursued. Even companies that do engage in open innovation cannot be simply assumed to need, to want, or to be able to involve external actors in all of their R&D&I undertakings at all times. One fundamental aspect of innovation emphasized by the literature is indeed the high levels of uncertainty it carries, in such uncertain terrain, placing hard expectations on the future directions that will be followed by companies, in terms of R&D&I engagement level, areas of interest, and openness of the innovative process, will be far from an exact science. Internal changes in leadership and strategy of companies can have various effects on their long-term R&D&I plans, in addition, economic recessions are known to commonly diminish the levels of R&D engagement in companies (see Brockhoff and Pearson, 1998). In face of such uncertainty, it may be reasonable to expect that the frequency of interactions for R&D&I topics between companies and any given university will fluctuate over time, as opposed to a steady pace of interactions that could be predicted with any accuracy.

In addition, some companies may simply not constantly engage in R&D&I activities, or not constantly perform these in an open format. However, whatever ad-hoc, one-off, interaction they may desire to have with a university still holds potential to generate successful innovation. While Technology Parks may be mostly interested in developing long-term relationships with companies, based on continuous (highly frequent) interactions, there is still some good to be done by engaging in one-time (or sporadic) interactions with companies.

Commonly, the geographical enclosure aspect of a Technology Park is emphasized in definitions found in the literature and elsewhere, where the long-term relationship between companies and a park, in terms of physical location, may be

deemed one of the essential traits that Technology Parks possess, or, if not, some form of contractual relation that implies repeated interactions over time. Meanwhile, many other types of entities may exist to perform university-industry interactions outside the realm of a Technology Park. For instance, TTOs (NITs in Brazilian jargon) are a common type of entity universities will possess to handle Intellectual Property licensing to private companies. When discussing one-off interactions, as opposed to long-term relationships with companies, it may seem that other actors in the innovation system (at any level) may be more fitting to attend to demands. However, as we will discuss further down in this section, Technology Parks can also choose to participate in “quick” interactions that do not involve contractual relations or otherwise long-term commitment to repeated interactions, and this is yet another characteristic that may differentiate Technology Parks from each other.

To summarize the first part of this subsection: the relationship between a given university and a company can be realized on an ad-hoc base (one-time or sporadic interactions), or on a continuous base (long-term, high frequency of interactions). While Technology Parks may focus on building long-term relationships with companies, two dilemmas come into play: (a) even in the presence of genuine long-term interest, there may be periods of time where companies cannot or will not have demands for R&D&I interactions with a specific university, and (b) even those companies which are not willing to develop a long-term relationship can still be of interest for a Technology Park and a university to interact with. Other actors will often be available for such ad-hoc interactions, but nevertheless Technology Parks may choose to deal with (some of) these demands themselves.

The case of PTEC-UFRJ provided interesting insights into these issues. We have identified three main tools to deal with the two issues mentioned in the paragraph above, these are: (i) contractual clause for mandatory cooperation, (ii) servicing the ecosystem, and (iii) the park as a service. The first two have been applied at PTEC-UFRJ, the last item has been planned but is still in the process of being operationalized. This section will be split below into three subsections to discuss each of the three items above.

7.2.2.1 Mandatory cooperation clause

In the case of PTEC-UFRJ, companies are assessed in relation to the potential for continuous interactions with the university that they hold. Considering that this Technology Park has operated exclusively under the model of physically hosting resident companies (although they have been working on implementing associated non-resident companies), this assessment of potential for interactions over the long-term attempts to ensure that the physical space will not be taken up by companies which might only be interested in one-off interactions or are not yet sure as to how a somewhat continuous relationship will be kept overtime with the university.

However, PTEC-UFRJ seems to be aware that R&D&I themes, even in the presence of genuine intentions companies might have for the future, are still subjected to much uncertainty. To mitigate this, the park has implemented a mandatory clause of cooperation in the contract it establishes with resident companies. This clause of cooperation is set on monetary terms for large companies and on a specific “score system” for SMEs, and is time limited (mandatory cooperation is effective over the first few years of joining the park). Under this contract, PTEC-UFRJ was careful to include a list of modalities of cooperation deemed acceptable to fulfil the mandatory obligations, and these modalities reach beyond direct R&D&I interactions (such as joint research projects), so companies are incentivized to cooperate with UFRJ by: donating equipment, licensing software, investing in the university’s infrastructure, and more. So while there may (and likely will) be times during which specific companies will simply not possess any demand for interactions directly related to performing R&D&I projects, PTEC-UFRJ still directs the companies towards cooperating with the university by explicitly proposing a clearly defined list of cooperation modalities (with room for suggestions) that expand beyond contracting services for R&D&I projects.

While such mechanism can be an option worth considering for other Technology Parks in the country which may, as of yet, not do something similar (or those which are still under planning/implementation), some challenges need to be considered. First, it is conceivable that such a clause of mandatory interactions, with a monetary threshold, will impact the likelihood of companies wanting to (or being able to) join the park. As indicated by some of our interviewees from PTEC-UFRJ, there was a perception in the

national scene that this park was indeed “tough” on companies, also due to the mandatory clause of cooperation (among other reasons such as service fee prices, and the renting of land instead of free concessions). It may be the case that PTEC-UFRJ was prone to not feel much negative impact from implementing such a clause due to the strong pull of the pre-salt Rush, and all the conditions that made the park particularly attractive for companies during that time.

[...] even the conditions we have established... We, UFRJ, have established for the companies, were very tough conditions. My colleagues from parks in other cities could not believe this. Because other cities would give away land, give away buildings, right? They would get on their knees for companies to go [there]. And we said: “no, you have to pay a rent, you have to pay a service fee, which is similar to a condominium, and you got to have projects for cooperation with the university in such amounts”. It was a very special moment for Rio de Janeiro, right? [...] (Interviewee N)

Later on, when the pre-salt rush slowed down, PTEC-UFRJ has indeed indicated that a revision of the values (and timeframes) defined in the mandatory clause of cooperation was needed, to make them a little more accessible. A special consideration here is that PTEC-UFRJ observed their values to have been defined according to the oil & gas sector, however, as diversification of sectors happened inside the park, a conclusion was reached that other sectors may simply struggle to meet the same level of investment performed by the oil & gas sector.

In much the same way that sectorial differences can play a role on the impact that mandatory cooperation clauses will have at resident/associated companies (and prospects), PTEC-UFRJ also recognized that expectations cannot be uniformly distributed across companies from different sizes. At first, large companies and SMEs had different monetary values to be achieved, later on, the monetary system for SMEs was substituted by a “score” system, so companies can fulfil their obligations based on type and frequency of interactions performed, as opposed to monetary amounts.

Another fundamental decision that need to be taken in case such a tool is applied in other Technology Parks is: will a clause for mandatory cooperation be effective indefinitely or for a specific amount of time? At PTEC-UFRJ, a decision was made to turn such a clause into a temporary mechanism. The reasoning behind this is that companies are expected to “learn” how to be pro-active in the relationship with the university, thus, a clause for mandatory cooperation should not be seen as some kind of punishment mechanism, instead, it is a tool to have companies getting used to

engaging with the university, not only by contracting services for R&D&I projects but also in many other ways.

[...] considering that Brazilian companies are not used to investing in R&D – you can look at all indices and compare to, for example, the OCDE [countries] indices and even other Latin American countries –, Brazilian companies, the Brazilian industry, is [very] little intensive in knowledge, research, and interact [very] little with universities. [...] So how do we deal with these companies? The hypothesis was: “let’s add this clause, this investment clause, because by adding this clause the companies will be motivated to get moving”. [...] But this clause was not really created with a positivist mindset, it wasn’t created to look at things that have not been done and charge a tax, a fee, it was created as a positive stimulus so that companies would really try to interact [...] (Interviewee D)

It seems that, ideally, such a mandatory cooperation clause should not be necessary, if Brazilian companies, in general, were expected to be pro-active in increasing (or maintaining) the intensity of their R&D&I activities while seeking out interactions with universities routinely, in diverse forms, without the need for much external pressure. PTEC-UFRJ found that this was not yet the case, and indeed this conclusion is backed up by data. The decision to make a mandatory cooperation clause temporary, instead of permanent, is optimistic in the sense that companies, which in the absence of such a clause would be expected to not interact much, are expected to learn and internalize (be “motivated”) a routine of interactions with universities and satisfactory levels of R&D&I activities over the long-term.

In the case of PTEC-UFRJ, both the required values (be it monetary for large companies or scores for SMEs) and the expiration date of the mandatory cooperation clause were reported to have been somewhat decided on an arbitrary basis. A subjective assessment of their specific attributes, in terms of sectors and sizes of companies they house, was made to reach the specified values and timeframe. Therefore, while a mandatory investment clause may be an interesting consideration for other Technology Parks in the country, it is important to notice that PTEC-UFRJ’s specific model may not necessarily apply elsewhere, and parks need take their own context into account when deciding whether or not to implement such a tool, the values to be demanded as mandatory, and expiration dates of this obligation (if any).

As of 2020 PTEC-UFRJ’s case still had not entered the phase where many companies have been out of the mandatory cooperation clause for a period of time long enough to provide accurate assessments of whether or not this tool has been effective in motivating companies to continuously engage in interactions. There are

two large companies still at the park who have joined prior to the mandatory cooperation clause being created, and, according to our interviews, these two companies have been displaying different profiles and levels of interactions with the university, one being more pro-active than the other, but nonetheless both have engaged in interactions multiple times in the past. A suggestion for a future study of PTEC-UFRJ (or other Technology Parks where similar temporary clauses have been set in place) would be to analyse the behaviour of companies after such mandatory clause has been expired for an extended period of time, to further investigate the real impacts of applying this tool.

7.2.2.2 Openness to external demands

Technology Parks may establish formal (contractual) links with resident/associated companies. Companies may need to undergo competitive selection processes and need to be approved in order to join as an official member. The case study analysed in this work fits this description, and shows that a challenge may arise in such circumstances. Technology Parks connected to a university (especially those which are successful) may end up as “the face” of the university in the eyes of companies who are interested in interacting with the academia. It may happen that some companies wish to interact with the university on an ad-hoc basis, as opposed to committing to a long-term formal relationship (contractual), and/or physically moving (fully or partially) into a Technology Park. A sufficiently known Technology Park linked to a university will likely be faced with situations where companies contact the park to attempt such ad-hoc interactions.

Brazilian universities that own, or are linked to, a Technology Park, will possess at least one other actor that deals with interactions with private companies, the NITs (Núcleo de Inovação Tecnológica, Brazilian equivalent of TTOs in the international literature), which have been mandated by law in 2004. In addition, other actors may exist within the university, who also deal with private sector interactions, such as Embrapii units, standalone incubators, other Technology Parks, and more. Therefore, the organization of the entire innovation ecosystem within the university (or universities) linked to a Technology Park will influence the behaviour of the park when dealing with those ad-hoc requests. On a superficial level, universities' innovation

ecosystems may be (or tend towards being) (a) centralized or (b) decentralized. A centralized ecosystem could facilitate the process of a Technology Park to handle ad-hoc requests from external companies in two different ways (or a mix of both): (i) the park could simply route requests to a central entity, who would be responsible for distributing demands to the competent actors, or (ii) the park itself would be the central entity responsible for distributing demands to the competent actors of the ecosystem. While a decentralized ecosystem, depending on the degree of superposition of roles and on the level of communication between actors, may not be as easy to navigate.

This is not to say that a centralized ecosystem with clear cut boundaries is necessarily the best model for a university's innovation ecosystem. For instance, in PTEC-UFRJ's case, the innovation ecosystem inside UFRJ has been characterized as a mostly decentralized model, which developed organically over time with UFRJ's long history of engaging in Technology Transfer and other industry interactions. Both centralized and decentralized ecosystems will vary in the degree to which superposition of attributions may exist, the higher the degree of superposition, the less trivial is the task of routing demands to the appropriate actor. Variance in the degree of communication and coordination between the different actors will also have similar impacts.

Discussing the advantages and disadvantages of a centralized vs. decentralized innovation ecosystem (with more or less degrees of superposition) inside a university lies very much outside the scope of this work. For the relevance of this discussion, suffice to say that both models are possible. During the analysis of the case study performed in this work, it has emerged that Technology Parks operating under a decentralized university innovation ecosystem may face an additional challenge regarding the handling of "external" ad-hoc requests ("external" here meaning organizations without any formal link to the Technology Park). In an ideal world, perhaps companies and other external actors would approach a university with a clear understanding of the ecosystem, clearly defined demands, realistic expectations, perfect knowledge of the policies and processes that should be followed in order to achieve their goals, and what are the relevant entities and individuals they need to reach out to. Naturally, interactions happen in far less idealistic scenarios than this, so demands from external organizations will often need both (a) a preliminary analysis done by individuals/teams who know the ecosystem from the inside (to assess

feasibility and clarify expectations) and (b) routing the demands to the competent actors (when not the recipient).

As said, the case analysed in this work demonstrated that Technology Parks may end up serving as the (or one of the) “face(s)” of the university in the eyes of private external actors who are interested in diverse types of interactions with universities. Because Technology Parks, if somewhat successful, can enjoy great regional or national recognition, surpassing the external visibility of other mechanisms (for interactions with the private sector) a university might possess. Because of this, Technology Parks may commonly come across ad-hoc demands from external organizations, and they may decide to serve them, despite the inexistence of formal (contractual) relationships between the company and the park. Taking it one step further, Technology Parks may also choose to actively reach out to external companies (non-residents, non-formally associated) in order to foment innovation and other cooperation projects. In summary, three modes of responses to external opportunities for interactions emerge: (i) closed, exclusively dedicated to serving formally associated and/or resident companies, (ii) open-passive, available to serve external ad-hoc demands, and (iii) open-active, accepting and reaching out to external organizations, proposing interactions.

Naturally, decentralized ecosystems with some degree of superposition of roles do not imply every actor is apt to serve any demand, it simply implies that some demands can potentially be served by more than one actor within the ecosystem. As a case in point, PTEC-UFRJ has lived within a mostly decentralized innovation ecosystem inside UFRJ, and has tended towards open modes of response. An example of open-passive behaviour was the case of a commercial bank reaching out to PTEC-UFRJ wishing to sponsor one specific project being conducted in the university, related to COVID-19. In this case, PTEC-UFRJ served as the entrance point due to its wide national visibility. Individuals at the park worked on articulating the connection between researchers and the company, despite this being a one-time ad-hoc demand from a company which is not formally connect to the park. Open-active instances have also been carried out, as an example, multiple interactions and attempts have been conducted with L’Oréal due to its physical proximity (although L’Oréal is also not formally bound to the park) among others.

Openness to interactions with external companies can also be demanded by individuals internal to the university. Researchers (and potentially students and employees too) may by their own initiative want to interact with companies. These individuals may usually need support from actors within the innovation ecosystem even if only for juridical consulting to understand what can be done and how, but they may also seek support to go through the entire process of finding potential partners and articulation with specific companies. When this demand involves companies linked to a Technology Park, it may be natural to contact the park's team to go through the process of interaction. However, for the same reasons a Technology Park may be “the face” of an university in the eyes of external companies, internal individuals from the university could also end up contacting the university's Technology Park to look for support with interactions also with external companies. In this case, the same discussion as before applies: closed parks may only route the demand to another actor in the university's ecosystem, open-passive parks will be willing to work on these demands on an ad-hoc basis, and open-active parks will routinely interact with researchers, students and/or employees to raise potential interactions that could otherwise go undetected.

While open-active responses do hold the potential to expand the horizons of potential innovation and of benefits to the university that can be generated, there is naturally a trade off in resource usage. The reason this is presented as a challenge for Technology Parks is therefore the balance that need be established in this relationship: how much effort, resources, and time can realistically be put into external interactions, passive and active, to harness the most opportunities from the environment? We propose that Technology Parks in early stages of planning and operations can benefit greatly from planning ahead processes and structures for this, should they decide to pursue open modes of response to external demands.

7.2.2.3 Associated companies

The term “Park as a Service” was mentioned multiple times by different interviewees in our case study of PTEC-UFRJ, this is a concept signalled as the future direction the Technology Park was headed towards. As discussed before, and a common topic in the literature, although Technology Parks (not only in Brazil but in

general) will possess similar goals in that university-industry interactions for R&D&I projects are the essential characteristic shared by most (if not all), still, there is a myriad of models of Technology Parks that exist today. One of the characteristics that varies across parks is the inclusion, or not, of associated companies that are not physically residents of the park, not even partly (with R&D centres). While for some parks the physical location of companies inside a well-defined land area designated for the park is a fundamental characteristic, other parks will blend both resident companies and non-resident but associated companies.

The reader will recognize the subject as similar to the external companies mentioned over the last subsection “openness to external demands”. However, the “openness” mentioned before was in the sense of accepting and/or reaching out to external companies for one-time interactions, without establishing, formally, any long-term relationship whatsoever. Whereas, here, “associated companies” is meant with the assumption of long-term (formal) relationships being developed, where the expectations for frequent interactions apply, similarly to the case of “standard” resident companies. Therefore, we have recognized three types of relationships between parks and companies that vary in terms of physical location (in vs. out) and continuity (frequent vs. sporadic): (i) continuous relationship as resident companies, (ii) continuous relationship as associated companies, and (iii) one-time, or sporadic, relationships as completely external companies.

In the case of PTEC-UFRJ, a consensus was found that expanding into the category of associated, but non-resident, companies may be a natural and positive direction the park should head towards. Since at least 2015 planning on how to operationalize such type of relationship has been kicked-off in the park, however, as of 2020, PTEC-UFRJ was yet to formally enrol any company under this title. Some of the challenges include: (a) public policies surrounding the subject might still need improvement to formally acknowledge this type of relationship between Technology Parks in public universities and companies. The 2016 update to the Innovation Law indeed included in its article #3 the provision of “strategic alliances” that can be formed between public entities and private companies, nonetheless, it seems a more explicit treatment of associated companies could still be needed to erase juridical uncertainty, and (b) a trade-off observed by Salomão (2019) between scalability of services and their effectiveness. The author analysed the effectiveness of services provided to

SMEs inside PTEC-UFRJ during the first implementation of the post-incubation program. The program included both individual and personalized support for companies as well as collective actions (condensed in the form of collective thematic events, meetings and workshops based on a diagnosis of companies). Salomão (2019) found that collective actions, while very scalable, were less valuable to companies when compared to the effectiveness of individual and personalized services.

As is noticeable, this last point was regarding the offering of services that deviate from the core activity of articulating actors (in companies and the university) for cooperation purposes, as the post-incubation program consists of business support services. What happens is the following: PTEC-UFRJ's case suggests that offering enough incentives to capture companies as formally associated, and paying, members of a Technology Park may demand the offer of services beyond the basic feature of articulation/mediation between individuals from a company and a university. In case associated companies do not dispose of additional services beyond the availability of personnel to aid in mediating communication with a university, companies may have an incentive to go the "informal" route of ad-hoc interactions when needed. If the Technology Park operates under an open model of accepting ad-hoc demands from external companies (non-residents and non-associated) for the greater good of the ecosystem, value-slippage may occur in the sense that companies may not be captured as associated members of the park, with responsibilities, because the basic service of articulations is available to them regardless of their status as formal members or not. This is different for companies that join as residents because the fact of physically moving into the park already implies somewhat of an additional value offered to companies, in the form of standard real estate business (land area for construction of R&D centres, slots in shared builds, etc) which can also include condominium services such as facilities maintenance, landscaping, security, reception, etc.

[...] I think we stumbled both in bureaucratic barriers, of how to contractually operationalize this within the public application process, and in barriers that [relate to] the trade-off we discussed before. Of how do [we], having a super small team, can grow the scale of [our] service presentation without compromising quality, and serving many people, while being able to deliver value. Exactly because the processes which effectively generated value were not scalable. [...] [We] would need a gigantic team to deliver this service. And, on the other hand, if [we] only offered "oh, I will have a schedule of open events for you", this was not necessarily valuable enough for companies to be like

“oh, so I want to be an associated”. Much because a good amount of events we held [...] already were open events. [...] (Interviewee K)

In summary, while the category of associated (non-resident) companies can be another venue for Technology Parks to develop long-term relationships with companies, hopefully generating interactions on a higher frequency rate while possibly ensuring another source of income to the park, it seems (i) there is a trade-off between openness to sporadic external demands vs. acquiring formally associated companies. When a Technology Park chooses to serve demands from external companies on an ad-hoc basis for the greater good of the ecosystem (without establishing a formal relationship between the company and the park), companies will only be incentivized to become formal members, with contractual responsibilities, in the case additional services can be provided, for example, business support services, consultancy, training and education, facilities, information, networking, etc (a possible exception here could be a case where brand association to a Technology Park would be enough of an incentive due to very high prestige), (ii) given the nature of services delivered by Technology Parks, be it core articulation services or additional services such as those mentioned above, the scalability of these may depend on a necessary growth of teams, and (iii) legal definitions for this modality still suffer from some degree of uncertainty.

7.2.2.4 Park as a Service

The conjunction of openness to external demand plus acceptance of companies in the modality of associated but non-resident is what PTEC-UFRJ has internally labelled a movement from “Park as a Site” towards the “Park as a Service”, a term that has been used by multiple of our interviewees.

[...] we also established an expression that is the “Park as a Service”. There is the “Park as a Site”, the place where [companies] install themselves, and we offer a package of services for university-industry articulation and interactions, but there is the other [option] which is only the offering of services, without any physical space relationship. And in this post-pandemic world, maybe we will come to intensify these new relationships [...] (Interviewee A)

[...] This thing about the park as a physical space is over, we need to sell the park, to build the park, as a service. [...] (Interviewee I)

Park as a Service would encompass either or both (a) open-active responses to interactions with external companies, initiated both from inside the university and

from companies themselves, and (b) establishing long-term contractual relationships with associated but non-resident companies. As we have seen, balancing both (a) and (b) carries a challenge that may force a park to offer additional services besides articulation for interactions to associated companies, however, scalability of some valuable services provided by a Technology Park is not trivially done due to their personalized nature (see Salomão, 2019).

While moving towards the concept of a Technology Park as a service does indeed open up potential for many more interactions and also income generation to a park, it is still unclear at which point does a Technology Park and other actors for university-industry interaction lose their distinctive characteristics. Both in Brazil and abroad there is a number of other types of organizations and entities, inside and outside universities, that work on enabling university-industry interactions. In Brazil, for example, there is the figure of Embrapii units, which may exactly cover the demands for university openness to external companies on a project-specific basis, in addition to NITs (TTOs) that handle Intellectual Property and licensing. Of course, while some Technology Parks may move towards the concept of “Park as a Service”, blurring even more the boundaries between different actors, the distinctive property of physical allocation can be kept concomitantly. But this begs the question of whether one or the other modality is more effective for both formal and informal university-industry interactions to happen.

Works such as Siegel, Westhead, and Wright (2003), Lindelöf and Löfsten (2004), Malairaja and Zawdi (2008), among others, have investigated differences between on-park and off-park companies in terms of research intensity, innovation, growth, and more. However, off-park here is meant in the sense of both non-resident and non-associated companies. We suggest that future research could investigate the differences in profile of resident companies and associated but non-resident companies of Technology Parks linked to universities, in terms of amount of interactions, innovativeness, growth, and more. If it is the case that associated companies can perform at comparable levels to resident companies (in different dimensions, e.g., formal vs. informal interactions), justifying the existence of on-park resident companies may become harder. Perhaps the justification could lie in the sole generation of monetary value to the university and/or the park through land concession fees and rent for shared space.

In summary, Technology Parks can choose between multiple modes of action regarding interactions through both long-term formal relationships and one-off single project articulations. We have observed a number of different ways parks may choose to deal with these through the case study of PTEC-UFRJ. Different types of relationships with companies will bring along different challenges that have been described throughout this subsection, however, we cannot attest which responses are objectively better. Technology Parks should take conscious decisions in regards to which model is to be applied, and further research may be needed to verify the impacts of difference responses mentioned through this section (mandatory cooperation clauses, openness to ad-hoc external demands, and associated non-resident companies).

7.2.3 Obvious vs. non-obvious interactions

It is proposed that companies may join a Technology Park holding a higher potential for interactions than what is perceived by the companies themselves. The bigger a university is and the higher the number of companies connected with a Technology Park, the harder it is for any one company to assess the full extent of possibilities available through the park. Personnel at a Technology Park will usually hold far more information regarding the university and other resident/associated companies than will individual companies do. PTEC-UFRJ's case shows that ensuring close attention to each resident company, understanding their activities, history and goals as best as possible, and frequently engaging in conversations with them, will yield the potential for the park to unveil more venues for interactions and to propose those interactions to companies. This could be re-worded as a difference between passive and active modes of servicing companies and the university. A Technology Park operating under a fully passive mode will wait for stakeholders to initiate an attempt for interaction, while an active instance will see a Technology Park analysing possibilities and proposing their ideas to companies and/or the university.

An additional implication is observed for the selection process of companies who wish to join a park. Technology Parks that operate with long-term physical hosting of companies may be pressured to accept only those companies who can demonstrate potential for interactions with the university before joining the park. In the case of

PTEC-UFRJ, some level of previous planning of interactions with UFRJ is analysed by a committee responsible for approving new companies. The following consideration emerges as a decision that has to be made by Technology Parks in similar situations: to which extent is the park willing to help companies that may be interested in performing open innovation and interactions with a university, but lack information and experience to properly assess the full potential of interactions before being accepted to join. On the one hand, helping companies to uncover potential synergies may expand the pool of prospects that end up joining a park, and may be a fitting strategy in the context of a country such as Brazil, which historically has not possessed high numbers of companies performing R&D&I, let alone open innovation. On the other hand, providing such support for candidates would naturally consume resources that could be directed to companies already established in the park, and would likely necessitate an increase in personnel. In summary: teams at a Technology Park ideally hold more knowledge about the university it is connected with and its resident companies than any one individual company does by itself. Regarding resident/associated companies, this offers the park an opportunity to actively propose interactions. Regarding prospect and candidate companies, this means the pool of interesting companies may be expanded by actively helping them to develop plans for interactions

7.2.4 Tacit and relational knowledge

Articulating companies and one, or more, universities demands that a Technology Park hold detailed information and knowledge regarding both sides, a necessary condition for effective matchmaking. For the most part, this knowledge is acquired via long-term relationships developed between the park's team and managers/entrepreneurs in companies, and diverse individuals in a given university (researchers, employees, and students alike). PTEC-UFRJ's case suggests that much of this comes in the form of tacit and relational knowledge that may be hard to codify and hard to transfer. The relevance of such knowledge is increased when a park decides to (a) take an active instance – to propose articulations to both parties, as opposed to simply waiting for requests –, since proposing articulations that hold real potential and are interesting for the parties requires more than superficial

understanding of entrepreneurs and the companies linked to the park. And (b) to offer business support services (in areas such as finances, HR, accounting, strategy, etc) to its companies, where a process of “diagnosis” is necessary to identify both explicit and implicit demands and “pain” points (terms derived from our interviews). In the case of PTEC-UFRJ, diverse mechanisms have been set in place that ensured continuous, frequent, and close interactions between (part of) the park’s team and resident companies. Frequent conversations, meetings, and events, both individual and collective, with the specific aim to diagnose companies, provided the park with the ability to understand its companies in great level of detail.

The challenging side of this regards the type of knowledge that arises thereout, which, as mentioned, may not be easily codifiable and/or transferrable due to its tacit and relational dimensions. The relevance of such knowledge for a Technology Park implies that anticipated provision and retention of personnel is key to a healthy existence. As was discussed during our analysis, it may be virtually impossible to find professionals externally, in the job market, that hold this very specific knowledge, that is, about specific universities and the group of specific companies linked to a Technology Park. Anticipated acquisition of personnel may ensure the transferring of such knowledge by virtue of prolonged teamwork, integrating new and old personnel. This is somehow in line with Penrose’s (1959) discussion on team work for developing entrepreneurial services, but note: while Penrose’s proposition regards entrepreneurial services for expansion, we suggest that such mechanism may be necessary for the efficient continuation of day-to-day operations of a Technology Park, avoiding abrupt breaks.

7.2.5 Retention of highly skilled labour

The case study analysed in this work suggests that Technology Parks (of comparable models to the one studied here) may tend to employ highly skilled labour to perform, support and manage its core function of articulations. Personnel with solid and varied professional experience in the industry, universities and/or public sector (government) entities, as well as strong academic backgrounds, not uncommonly holding graduate level degrees and being researchers themselves. Naturally, being at the intersection of academia, the industry and the government, a Technology Park in

such format needs personnel able to navigate these three spheres. Additionally, some of our interviewees suggested that lean hierarchies and small teams may be a common characteristic of Technology Parks and general innovation environments in Brazil. In which case, a Technology Park would be incentivized to acquire Human Resources that offer the most varied and qualified skillsets as possible, such was the case of PTEC-UFRJ.

Where the above is true, the following challenge emerges to be resolved: while lean hierarchies may pressure for the acquisition of highly qualified human resources, retaining such highly qualified personnel may in turn be more difficult due to reduced prospective for future professional ascension. This issue may be even more challenging for parks operating under comparable judicial forms as that of PTEC-UFRJ, which means assuming a public entity character. Under such circumstances, accumulating slack financial resources may be constrained by regulations, where financial slack could serve as one tool to aid retention of highly qualified Human Resources. As pointed out in some of our interviews, such professionals are in high demand and not easily found in the market, this, coupled with the considerations made above, suggests that retention of such personnel could indeed be one major challenge to be overcome.

In connection of the challenge presented before, in section 7.2.4, retention of personnel in Technology Parks may be even more critical for the healthy existence of a park due to tacit and relational dimensions of knowledge held by human resources. Anecdotally, our case suggested that the ties developed between a park's personnel and managers of resident/associated companies could be, at times, so strong to the extent that companies may choose to abandon a park when abrupt changes of personnel occur. And this again may result from operating with lean hierarchies and small teams, as close relationships can be established between companies and single, specific, individuals at the park over time.

In summary, for Technology Parks where the pressures mentioned above are true (lean hierarchy, small teams, low financial slack constrained by regulations, essential role of tacit and relational knowledge, and low availability of qualified professionals at the market), retention of personnel is both more difficult and more critical. We propose that Technology Parks in Brazil still in their planning or early stages may benefit from giving special attention to this challenge. Much discussion on the

academic area of management has already been produced regarding mechanisms for retention that go beyond monetary compensation and opportunities for advancement in hierarchies (e.g., Mitchell, Holtom, and Lee, 2001; Budhwar and Bhatnagar, 2007; Govaerts et al., 2011; Oladapo, 2014).

7.2.6 Integrating companies among themselves

While the primary objective of a Technology Park linked to a university may be to articulate companies to the university and vice-versa, our case demonstrated that articulating companies among themselves is indeed another source of value that can be offered to companies. In both scenarios, our case suggests that physical proximity may not be, by itself, a sufficient incentive to spark formal interactions, demanding some level of active participation of the park's team. The challenge of integrating companies among themselves may be stronger for Technology Parks that congregate large companies, SMEs and startups under the same environment. Emerging from the case here analysed, SMEs and startups may be disproportionately more interested in interacting with large companies than the other way around, and integrating these companies may be an explicit demand received by the park.

Some factors which emerged from our case analysis are deemed to influence the easiness of integrating companies. The two most relevant are: (a) our interviews noted the existence of sectorial differences in the attitude towards SMEs, where large companies in some economic sectors may be more willing, and accustomed, to interact with start-ups than large companies in other sectors may be. For instance, the oil & gas sector was considered to be challenging in this aspect; and (b), the ability of a Technology Park to access areas other than R&D centres of large companies may, at times, be impaired. When considering the model of physically hosting large companies as long-term residents, Technology Parks may end up with strong links to R&D centres of large companies (R&D managers and other personnel involved in the research centres). Yet, the relationship between the park and other areas of these large companies may be weak or non-existent, when the following conditions are true: (i) large companies possess well defined (to some extent, rigid) bureaucratic processes for establishing commercial and strategic relationships with any other company, and the process of being deemed fit to join the value chain may be too complex for many

start-ups and SMEs to accomplish by themselves; (ii) management of R&D centres may lack any power to participate and/or decide in commercial and strategic relationships carried out by the company; and (iii) Technology Parks establish formal relationships with R&D managers and other personnel directly involved in the operations of R&D centres, but this relationship does not imply any formal mechanism for interacting with other areas of these companies, such as commercial, finance, higher management (strategy), etc. In fact, even consolidated communication channels (whether formal or informal) between a Technology Park and decision makers of large resident companies may not be a given. A strong characteristic of the case analysed in this work was the presence of multinationals headquartered abroad. In this situation, such articulations may be even more challenging, as often is the case that Brazilian subsidiaries of multinational companies will have their R&D objectives and guidelines set abroad, where little to no room may be made for local adjustments, such as partnering or acquiring technology from local SMEs and start-ups. To paraphrase one of our interviewees, R&D managers, and other personnel involved in the R&D centres located at a park, may be very interested in partnering or acquiring technology/services from SMEs and start-ups located at the park, but they may also simply lack the tools to realize any of this potential. When R&D managers perceive their power to influence decisions to establish commercial or strategic relationships with other companies as low, this can, for instance, manifest as an apparent lack of interest in joining events promoted by a Technology Park to integrate companies.

In summary, Technology Parks may generate value for residents/associates also by articulating companies among themselves. Parks that congregate both large companies and SMEs may especially face this demand explicitly by SMEs and startups who wish to engage in commercial relations with large companies in a park. We propose that Technology Parks that seek to integrate companies among themselves can benefit from establishing relationships and communication channels with decision makers of companies beyond R&D managers and personnel. As an example, one tactic to integrate companies employed by PTEC-UFRJ was to promote events with the specific theme of integrating SMEs and large companies, by having SMEs present their services and products, and large companies present their demands and objectives. However, it was found that such events may not produce much results in

case representatives of large companies simply lack the ability to decide whether to engage in such relationships or not.

7.2.7 Summary of management challenges derived from PTEC-UFRJ

Because the analysis of PTEC-UFRJ in light of Fleck's (2009) theoretical model required the collection of detailed longitudinal data regarding one of the most prominent Technology Parks in Brazil, a list of challenges that can potentially be faced by other parks in similar contexts has been compiled as a secondary objective of this work. By doing so, the data gathered from our analysis of PTEC-UFRJ could be used in a contribution, even if minor, to the literature on Technology Parks. A summary of the challenges is provided next:

Legitimacy beyond technological R&D&I projects: Expanding into non-R&D&I projects including diverse areas of the university, with or without the participation of companies, may be necessary to maintain the legitimacy of a park inside a public university. Interactions with groups that would otherwise be alienated from the activities of a park and generation of a wide set of benefits to students, professors/researchers, and employees alike can aid in maintaining legitimacy. This can include areas related to culture, arts, social and environmental projects, as well as job opportunities and contracting professional services from spin-off companies and professionals linked to the university.

Long-term relationships vs ad-hoc demands: There are cases in which expectations for continuous/frequent interactions may not be interesting for some companies, but, still, potential for good interactions exist. Even in the case of companies that choose to join in on a long-term relationship, it may be expected that the amount of interactions for R&D&I projects will fluctuate over time. Technology Parks may implement mandatory cooperation clauses with provisions for types of interactions beyond R&D&I that can still benefit the university nonetheless during periods in which a resident company does not show high demand for interactions. Parks may also be open to ad-hoc interactions with external companies, disregarding the need for a long-term relationship with frequent interactions (open-passive and open-active). Finally, some companies may be interested in a long-term relationship with respect to interactions with a university, but not interested in (or able to) physically

move into a park, in this case, Technology Parks may implement the modality of associated but non-resident companies.

Obvious vs. non-obvious interactions: (i) Personnel at Technology Parks, ideally, will possess detailed knowledge regarding the university (academic expertise, research areas, junior companies, prominent researchers/students, etc) that is not on the radar of companies. (ii) Companies may have “blind spots” for areas of research that could have synergy with their operations. And (iii) Technology Parks will ideally possess detailed understanding of their resident/associated companies, which should facilitate the identification of potential interactions between companies that could otherwise go unnoticed by them. Non-obvious interactions will fall into one of these categories. Technology Parks that choose to take a more active instance in generating interactions, as opposed to waiting for demands to arise, may work on proposing such non-obvious interactions to resident/associated companies. A move into this direction may require management to dedicate resources and build processes around uncovering such potential, if they are to happen with some consistency.

Tacit and relational knowledge: Tacit knowledge regarding the history, functioning, challenges, and objectives of both resident/associated companies and diverse groups of a university, acquired by people involved in the management and services of a Technology Park, is arguably the most valuable resource a park might have. As well as social ties developed with individuals both in companies and the university. It is virtually impossible for professionals to be acquired from the external job market possessing this knowledge and social ties beforehand. This implies that anticipated acquisition, appropriate internal succession mechanisms, and retention of human resources is critical for Technology Parks to maintain a healthy existence. What may be an acceptable turnover rate in most other types of organizations could be inadequate for Technology Parks.

Retention of highly skilled labour: The nature of services provided by Technology Parks may require people that possess great professional profiles, in terms of academic backgrounds and industry experience, as well as soft skills and pro-activeness. Also, according to interviewees, management of innovation environments require specific knowledge that is not commonly available (in the Brazilian context), but is highly demanded. Technology Parks born out of public universities in Brazil may struggle to retain such talent if operating under lean hierarchies where room for

continued hierarchical growth and/or exploring new professional areas is impaired. Also, low financial slack may be common across Technology Parks, and acquisition of financial resources to afford high compensation for labour may be difficult.

Integrating companies among themselves: There exists potential for innovation and growth of companies in a Technology Park through interactions between residents/associates among themselves. This may be specially the case in Technology Parks that congregate both SMEs and large companies, where the park may be faced with an explicit demand from SMEs who wish to interact with large companies for commercial purposes. Easing such integration is not trivial if Technology Parks cannot co-opt decision makers from other areas of large companies outside R&D centres, specially representatives of commercial areas and strategic management of these companies. Large companies will usually possess bureaucratic barriers to interacting with companies, which R&D managers (and other R&D personnel) can often struggle to exert any influence upon.

8 Conclusion

The main purpose of this work was to analyse the case of UFRJ's Technology Park in light of Fleck's (2009) Archetypes of success and Failure and the challenges of growth set forth there out. While the applicability of this theoretical model has been previously tested in a wide range of types of organizations, SMEs and large, government-held and private, familiar and public, and from different sectors, the case of an hybrid organization at the intersection of the government, industry and universities such as a Technology Park provides a testing ground for the model. Throughout this study, we have encountered a number of challenging aspects of such a hybrid organization that might make the application of this framework not too trivial. A recurring theme in the process of analysis was the ambiguity at which some elements of the Technology Park could fit into the categories defined in the model or not. Especially in the case of PTEC-UFRJ, which is not an independent organization but one of the many parts of a single university, the boundaries between what is in-fact part of the Technology Park or part of the university need careful attention (for instance, laboratories located inside PTEC-UFRJ are in reality COPPE's laboratories). Furthermore, choosing the relevant aspects to form a picture of the institutional environment is not a trivial task. For Technology Parks are hybrid organizations at the intersection of the industry, government, and academic worlds (see Triple Helix model, Etzkowitz and Leydesdorff, 2000), the number of actors and policies that may influence a given Technology Park is greatly expanded. Also, matters of Entrepreneurial services need be assessed by taking into consideration the conceptual and legal limitations faced by a Technology Park if they are part of public universities and other public research institutions, especially, Versatility and Fund-raising (Penrose, 1959) will be directly limited by policies and the very concept of why Technology Parks exist in the first place.

This work assumed the following proposition to be true: regardless of whether or not a Technology Park is successfully generating innovation and positively impacting the socio-economic development of a region, they might still cease to exist due to inadequate responses to management challenges not directly related to themes of innovation. Therefore, the assessment of successful innovation, interactions, and economic impact of a specific Technology Park does not exclude the need for an assessment made in light of strategic management theory.

It is true that Technology Parks could theoretically be kept alive even in the absence of adequate management, especially due to government interventions. However, while public funding is indeed expected to be an important resource for Technology Parks, and parks born inside a public university will naturally utilize public resources, authors such as Koh, Koh, and Tschang (2005) have suggested that a transition from government-led growth to private-led growth is desirable, and Radošević and Myrzakhmet (2009) have suggested that:

The key point is to distinguish between support for TP activities (cooperation with R&D and higher education institutions, active management of TT [Technology Transfer], and support for technology-intensive activities) and support for TPs as organisations. Rather than focusing on TPs as organisations, policy should focus on and prioritise support, first, to innovation projects (grants), second, to the people who will be involved in managing innovation projects (skills) and, third to supporting TPs as organisations. (Radošević and Myrzakhmet, 2009, p. 655)

Therefore, it is not desirable that Technology Parks, over the long term, continue to exist on “life-support” from governmental interventions. Although such state of existence can be expected, or even necessary, to enable parks to come into life and function during their early stages of existence (Koh, Koh, and Tschang, 2005; Radošević and Myrzakhmet, 2009).

The case of PTEC-UFRJ has been analysed in this work according to their responses to management challenges that can impact the park’s long-term healthy existence. Future research should be conducted to analyse PTEC-UFRJ’s impacts on innovation in the region and its socio-economic relevance. In this sense, the two modes of analysis are complementary and non-exclusive.

The analysis of PTEC-UFRJ in light of the challenges of organizational growth (Fleck, 2009) has yielded mixed responses. Responses to the challenge of Enterprising and navigating the environment were deemed mostly adequate, while the challenge of Human Resource Provision has been observed to need improvement, especially in terms of timing (anticipation) and mechanisms for succession. Managing diversity was deemed to have shown mostly adequate responses, but a main difficult aspect of it was found in the integration of resident companies among themselves. The challenge of managing complexity was the only challenge this work has abstained from delivering an assessment in terms of adequacy of responses, for our data was deemed insufficient to such analysis. It was also found that the central mechanism of slack-generation was behind adequate levels, especially Human Resource slack and

financial slack. However, legal limitations do contribute to the performance on financial slack, as does the difficulties that may arise with delays and shortage of funds acquired through public entities such as FINEP, moreover, generation of financial slack has been observed to be on a positive trend for the past five years.

Although the final assessment suggests that PTEC-UFRJ has not yet approached the vicinity of a self-perpetuating archetype (Fleck, 2009), the development of adequate responses to some challenges in such a short period of time may indicate a trend towards the self-perpetuating pole. For instance, the challenge of managing diversity revealed difficulties mostly in integrating companies among themselves, however, PTEC-UFRJ has been aware of this challenge and has been actively developing efforts to improve on this dimension, as opposed to negligence, and trends in the environment have been observed to move towards helping in this regard. Managing complexity was not assessed as either adequate or inadequate, but data was collected that showed PTEC-UFRJ has also not neglected this challenge.

According to our assessment of PTEC-UFRJ, the park has the most to gain from implementing changes related to the challenge of Human Resource Provision. Anticipated provision of Human Resources to the park seems critical due to tacit and relational knowledge carried by personnel, necessary to maintain the effectiveness of services delivered. This knowledge is virtually impossible to be found in the external job market to the extent they relate to the very specific set of companies and entrepreneurs located at the park and to individuals, groups and entities inside a specific university. Deep social ties between personnel of the park and entrepreneurs of resident companies may be expected to arise, due to frequent and close interactions, and abrupt severance of these relationships could impact the willingness of companies to remain at the park or have otherwise negative outcomes. In this sense, anticipation in providing Human Resources is needed to enable effective succession mechanisms, in addition to the benefits mentioned by Penrose (1959) in regard to developing essential entrepreneurial services for future expansion. Furthermore, PTEC-UFRJ is currently working on acquiring members in the modality of resident but non-associated companies, while this provides potential for much expansion, a concomitant growth in the amount of Human Resources may be necessary in order to deliver the most valuable services offered by the park.

In the challenge of managing diversity, it was found that in order to facilitate the integration of SMEs and large companies, the park might benefit from establishing relationships with decision makers in other areas of resident companies outside their R&D centres. The participation of individuals closer to commercial and strategic areas of large companies in the network of a Technology Park may be necessary to facilitate the process of interactions due to bureaucratic structures of large companies. However, these relationships can understandably be difficult to establish in a consistent fashion, especially in the case of multinational companies.

Overall, PTEC-UFRJ does not seem to be at the risk of ceasing to exist due to self-destructive behaviour as of currently. While the assessment in light of the theoretical model applied in this work can indirectly capture themes of socio-economic impact and innovation through the dimension of legitimacy. A future research aimed to the analysis of PTEC-UFRJ specifically in terms of socio-economic impact would therefore be a much-welcomed compliment to this work.

Because the process of constructing this work required the collection of detailed data regarding PTEC-UFRJ, a secondary objective was set to synthesise lessons learned from PTEC-UFRJ's case related to specific challenges faced by Technology Parks owned by public universities in Brazil. Given that PTEC-UFRJ is one of the most prominent parks in Brazil and the popularity of this type of organization has been growing in the country, with many young or still-to-come Technology Parks emerging over the past few years, we understand that the detailed data collected in this case study could be valuable for the literature on Technology Parks. Having this in mind, section 7 was concerned with the secondary objective of compiling a list of challenges that can potentially be pervasive across Technology Parks in Brazilian public universities. Younger Technology Parks, and parks still to come, have the benefit of hindsight into the experiences of other parks in the country, and this work contributes to the pool of information available regarding these experiences. The following six challenges have been compiled: (1) Legitimacy beyond technological R&D&I projects; (2) Long-term relationships vs ad-hoc demands; (3) Obvious vs. non-obvious interactions; (4) Tacit and relational knowledge; (5) Retention of highly skilled labour; (6) Integrating companies among themselves.

Limitations of this work include: (i) The Technology Park analysed here is a relatively young organization (less than two decades in operations), observable

patterns in responses to the challenges of growth may thus not be as strong as desired. However, Technology Parks are a new phenomenon in Brazil, and the one studied here is, in reality, among the oldest examples in the country. On the one hand, the popularity of Technology Parks in economic policies and the potential they hold for positive effects in development turn their study into a relevant discussion for the present moment. On the other hand, it is expected that studies into Brazilian Technology Parks will produce better insights in the future, when their history allows the collection of more data and a stronger footprint of patterns can be observed; (ii) The case study represents just a single piece of the universe of Technology Parks operating in Brazil as of today. Given that models of Technology Parks can vary greatly and their environment also changes considerably from region to region, readers are advised to not take this case as general representative of how Technology Parks are structured, managed and operated in Brazil; (iii) Environmental boundaries, as previously discussed, do not come close to encompassing all of the immediately relevant variables, events, and actors impacting the selected case, let alone Brazilian Technology Parks in general. However, past and future case studies of Brazilian parks utilizing different sets of boundaries for describing the environment can complement each other and provide a broader and comprehensive picture of the Brazilian context, forming a complementary literature that will hopefully be able to provide readers with a greater picture of the Brazilian Innovation System and its history; and (iv), this work relied heavily on interview data with recollection of past events that happened in the course of many years. The accuracy of information, perceptions and opinions regarding past events can naturally have been coloured by subjective interpretations of interviewees. Furthermore, the scope of interviews gathered for this work was limited, given that only a subgroup of stakeholders was reached.

As mentioned before, in this work, the PTEC-UFRJ was taken as an organizational unity in itself. Naturally, the Technology Park is formally but one integrating part of the university, as opposed to completely independent. Future research into this specific case may benefit from taking a broader perspective by incorporating UFRJ as a whole into the analysis. This does not mean simply collecting data regarding the Technology Park from other stakeholders inside the university, but actually incorporating the challenges faced by the university as a whole, uncovering how seemingly indirect themes may impact the Technology Park.

In the same line, future studies can also benefit from incorporating even broader frames of analyses, by focusing on the larger set of legal and bureaucratic barriers impacting the Technology Park, by analysing in-depth the regional private sector R&D&I processes and challenges, and/or by applying a fully-fledged ecosystem analysis of all the players in the Brazilian innovation scene which impact and are impacted by the Technology Park.

Despite the limitations mentioned above, we believe that the matter of Technology Parks and university-industry interactions are of great relevance to Brazil in its current context, given the popularity of such organizations and interactions that have been put to practice over the last two to three decades in the country. We encourage further studies into these organizations, considering the national context, in light of public and/or business management theories, as these could shine further light into the specificities of challenges faced by Technology Parks in Brazil that may not be captured by direct assessments of socio-economic performance, but nevertheless also help explain the outcomes observed in this regard.

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